PSYCHOLOGICAL EFFECTS

of

THE SURGICAL TREATMENT OF EPILEPSY

Valerie M. Cairns

Ph. D Degree University of Edinburgh

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SUMMARY

An investigation of the psychological effects of a range of neurusurgical procedures in the treatment of epilepsy was carried out in a total of seventy-one patients. This included a study of the effects of electrical stimulation of the amygdala in six cases. Detailed results of small numbers undergoing three main neurosurgical procedures are presented. In general, there was a post-operative decrease in disturbed behaviour, with a slight transient decline in level of cognitive function. This reversed in the longer-term following bilateral stereotactic amygdalotomy, but tended to be more persistent after placement of stereotactic lesions in central areas of the brain. These two groups also showed a differential pattern of change on self-report techniques relating to personality, mood and attitudes. Groups were not distinguished by changes occurring on a checklist method of assessment of behaviour. An unexpected finding was similar improvement over time in some non-surgical cases, although it was possible to distinguish the amygdalotomy group as showing a greater decline in stubborn, rebellious behaviour. The study describes an attempt to develop measures of frustration tolerance. Improved behaviour was not restricted to cases with improved control of seizures which occurred in a number of patients undergoing each of the main neurosurgical procedures. This did not appear to be reflected in any significant increase in occupational activity or decrease in the need for hospitalisation. In addition, psychological function in the larger group of one hundred and twenty-one

patients undergoing neurological investigation of epilepsy is described in terms of type of epilepsy, age of onset of epilepsy, and a comparison is made between cases selected for surgery and non-operated cases.

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INTRODUCTION

INTRODUCTION

This is a study of cognitive function, personality and behaviour in patients undergoing surgery for epilepsy or for behaviour disorder associated with epilepsy: also describing psychological functioning of a group of patients undergoing neurological investigation of epilepsy, but in whom no neurosurgical procedure was indicated.

"Are particular neurosurgical procedures associated with particular patterns of change in cognitive function, personality and behaviour?" This is the major question under consideration.

To neurologists and neurosurgeons in whose day-to-day clinical experience structural or functional changes in the brain are mirrored by (often dramatic) changes in behaviour it sometimes comes as a surprise that many of those specifically engaged in the scientific study of behaviour (psychologists) have little interest in the neurophysiological correlates of behaviour. In its struggle to emerge as a science over the past hundred years, opinions in many areas have oscillated, as in the field of abnormal psychology.

"Psychiatrie ohne Neuropathologie." It has been suggested by Zangwill (1973) that this might have been Freud's slogan.

In contrast is the opinion that "for every twisted thought there is somewhere in the brain a twisted protein molecule" (Halstead, 1958).

At an intermediate position, it might be postulated that any disorder of physiological function produces a condition of stress within the organism with possible repercussions in overt behaviour. "A paroxysmal and transitory disturbance of the functions of the brain which develops suddenly, ceases spontaneously, and exhibits a conspicuous tendency to recurrence", as Lord Brain (1962) defines epilepsy/

epilepsy, might be regarded as a particularly stressful disorder. Epilepsy and disturbance of psychological function have been causally linked by different authorities in different ways. Seven possible relationships are listed below:

(a) That epilepsy is a causal factor in a psychological disturbance of a reactive type - a learned pattern of responses to the occurrence of seizures, the emphasis in this approach being on the social, interpersonal aspects of the sufferer from epilepsy.

(b) That the frequent occurrence of epileptic seizures produces alterations in brain function which result in psychological disturbance (intellectual deficits have been explained in this way).

(c) That organic brain damage results in both epilepsy and psychological disturbance (often quoted with reference to perinatal damage or trauma at any stage of development).

(d) That there is neurophysiological evidence of epileptic activity (detected using electroencephalographic methods) in the absence of overt clinical seizures, but with a disturbance in psychological function; often characterised as consisting in impulsive outbursts (labelled as "epileptic equivalents").

(e) That there is a temporal sequence in which the typical course is of increasing behavioural disturbance culminating in an epileptic seizure. "Subclinical irritative disturbance" is a term used in this relationship and in (d) above.

(f) That there is an inverse temporal relationship between seizures and behavioural disturbance. (This may be related to (e) above).

(g) That in one phase of a seizure or in one type of seizure, disturbed/

disturbed behaviour may be observed in a setting of altered consciousness. (This might consist in a disturbance of attention and in an act of automatic behaviour in which a goal is blocked - a typical example being that of the patient in a seizure state pushing someone who is trying to restrain him, out of the way).

These seven relationships are discussed in the section on the review of literature.

They are not regarded as mutually exclusive. Neither is it held that epilepsy is a sufficient condition to result in some form of long-term psychological disturbance. Nor is it a necessary cause of psychological disturbance. In other words, there are many cases of epilepsy in whom there is no reason to suppose that there is a disturbance of psychological function and similarly the majority of cases of disturbance of psychological function occur in the absence of epilepsy.

Referral of cases of behaviour disorder for neurosurgical intervention appears to assume a neuro-anatomical base for the disturbed behaviour, or at least the location of pathways in a system regulating specific patterns of behaviour at a neurophysiological or biochemical level.

Where cases of epilepsy and behaviour disorder are referred for neurosurgical treatment of epilepsy, then this assumption is not necessarily being made. In these cases the behavioural disturbance is sometimes seen in the reactive framework described in (a) above.

In this study a number of different neurosurgical approaches to the treatment of epilepsy are considered. The emphasis is on the effect of the neurosurgical procedure per se, on the individual, rather/

rather than emphasising the effect which a change in the pattern of seizures has on psychological function. Within the population of patients with epilepsy (usually estimated as 1 in 250 or 0.4% of the general population in most countries) neurosurgical treatment is likely to be considered in only 10% of cases of epilepsy. Thus the sample in the present study is a small, biased one, drawn from 0.04% of the general population.

The term "epilepsy" represents a set of symptoms and signs rather than a disease. This makes it difficult to estimate prevalence since this requires a definitive categorisation of a case as "epileptic" or "non-epileptic." Further attempts are usually made within the "epileptic" category to classify cases on the basis of either:

(i) aetiology (for example, as idiopathic or symptomatic), or

(ii) putative location within the brain of the source of abnormal electrical discharge (the temporal lobe, cingulate, centrencephalic epilepsies), or

(iii) type of seizure (grand mal, petit mal, Jacksonian, psychomotor).

None of these methods has been found satisfactory, as is indicated below in reviewing the literature and discussing methods.

It has been mentioned already that the evaluation of psychological function is considered in this study in terms of "cognitive function", "personality" and "behaviour." Since these terms are subject to different definitions it seems most appropriate to define operationally the processes being evaluated in the individuals in this study. This is done as the specific techniques of psychological assessment/

assessment are described in the section on methods. However, prior to reviewing the literature and stating the hypotheses to be tested, it may be necessary to provide broad outlines of the psychological functions under consideration.

(a) Cognitive function: in this study refers to areas such as reasoning, language, memory, perception and attention. It is recognised that it is somewhat artificial to distinguish these from the use of the term (b) behaviour - which in this study is used to describe the activities of an individual which have been directly observed by others, but usually excluding activities providing a measure of the cognitive processes inferred in (a).

(c) The term Personality is indicated in the methods section to refer only to data obtained through self-report techniques designed to evaluate relatively enduring traits and attitudes in an individual. However, in reviewing the literature it is necessary to consider a much wider definition, often corresponding with the areas in this study covered by the heading "behaviour."

The goals of scientific enquiry have been stated as describing, predicting and controlling events in nature. This study is not exceptional in having aimed initially at a predictive goal, but on closer examination of the problem being limited to a descriptive framework. One reason for this is the complexity in defining the variables involved in all three areas - epilepsy, psychological functioning and neurosurgical procedures. This is indicated above and is emphasised in the ensuing review of the relevant literature.

REVIEW OF THE LITERATURE

REVIEW OF THE LITERATURE

"The seat of the seizure disturbance is the brain."

"Epilepsy is the work of the devil."

Illusions about the unique progress of science in the twentieth century are destroyed by the information that the above quotations are in correct chronological order. It was Hippocrates in 400 B.C. who put forward the idea that the seat of the seizure disturbance is the brain. A rather less well-informed present day figure - American star Pat Boone - is credited with the statement that epilepsy is the work of the devil (McCall's Magazine, 1973). That such a statement can be made today must be regarded as a sad failure in education. There is no shortage of reading material. However, of the 1,550 articles on epilepsy, abstracted by Excerpta Medica in 1972, only a very small minority are designed for the lay reader. Even for those with specialist knowledge, the sheer volume of the literature and the diversity of the field can be overwhelming. It is essential to make some selection and to organise the material in this selection.

A study of any aspect of behaviour in relation to epilepsy is possible only where the term epilepsy is specified. The difference in the degree of disturbance between the momentary absence, the full blown convulsion and the complex psychomotor attack must be obvious to any witness. Much of the confusion about research findings stems from misunderstandings on the part of readers, and failure to make explicit on the part of authors, criteria used in classifying aspects of the epileptic disturbance. Usually a combination of electro-encephalographic (EEG) and clinical (seizure pattern) data is used. In/

In investigations of some specific variable (such as spike-wave bursts on the EEG record) and psychological function, there is little confusion. The problems are particularly poignant, however, in investigations of psychological function seeking to discriminate between patients with different "types" of epilepsy.

Among the most eminent workers in the field of epilepsy, there continues to be disagreement about satisfactory methods of classification. Gastaut (1964) proposed a system of classification, for international use, of both seizures and of the epilepsies. This system has been regarded by some as unnecessarily elaborate. A number of authors are concerned with describing the features of a highly selected group of patients, rather than using an all embracing system. Within the partial epilepsies, a variety of terms has been used. Gastaut suggested five categories of seizures, the first two being far the most important and common. These are:

"1. <u>Partial seizures or seizures beginning locally</u>

A. With elementary symptomatology (motor, sensory or autonomic symptoms):

B. With complex symptomatology (automatism, ideational, psychosensory, psychomotor, etc. symptoms):

C. Generalized seizures with local onset. (N.B.: All partial seizures can develop into generalized seizures, sometimes so rapidly that the local features may not be observable).

2. <u>Generalized seizures or seizures without local onset</u>

A. Absences of differing form and duration, including "absence status." Absences may occur alone, or in combination with myoclonic jerks, or with increase or loss of postural tone, or/

or with automatisms.

B. Generalized convulsive seizures, in the form of tonic, clonic, tonico-clonic and/or myoclonic attacks."

In Category 1, the preponderance of, and the interesting concomitants of seizures associated with the temporal lobe and its underlying structures have led to the overshadowing of the other partial seizures. The name used for this category varies, depending on whether the emphasis is on (a) anatomical localisation of the epileptogenic focus, (b) neurophysiological systems, or (c) the clinical seizure pattern.

In the two major series of surgical investigations, those of Penfield in Montreal and Murray Falconer in London, the term "temporal lobe epilepsy" is used. Others (Mignone et al., 1970; Stevens, 1966) studying psychological disturbance prefer the term "psychomotor", while Glaser (1968) argues for the use of "limbic" epilepsy, since some patients with temporal lobe epilepsy do not have psychomotor disturbances and some patients with psychomotor epilepsy have indications of involvement of other than actual temporal lobe structures. Most authors do present some rationale for their use of particular terms. The confusion arises when people try to compare the results obtained from those overlapping, but not identical classifications.

The concept of centrencephalic epilepsy, a term used by Penfield and Jasper (1954) and implicated in Gastaut's second category, has been questioned by Williams (1965, 1968) insofar as the term implies that the abnormal electrical discharge is held to arise in diencephalic or mesencephalic structures. He argues that it/

it is more plausible to consider a cortical origin with discharges then passing through central pathways. He questions whether all epileptic seizures may not be local in onset. Williams does not deny the value of classifying types of epilepsy. He warns against over-simplification. For him, the distinction between partial and general epilepsy is extremely important, with the need for greater understanding of why the partial seizure does not always progress to a general seizure.

Perhaps psychologists are premature in their attempts to elucidate relationships between specific aspects of epilepsy, when so little is established about the nature of the epileptic process? Such deficiencies do not seem to be limited to the study of epilepsy. In the Annual Review of Psychology (1970) there is a paper on psychological deficit in schizophrenia and organic brain damage, by Zimet and Fishman. They criticise the bulk of recently published studies on two grounds. The first is failure to use adequately differentiated groups when making comparisons. This is exactly the point dealt with in the foregoing discussion on classification of epilepsy. Their second major criticism is of failure to demonstrate that the tests used were measuring the specific psychological function under investigation. Many apparently contradictory findings about psychological function in epilepsy can be explained by different interpretations of what is being measured.

A further source of confusion in the field of epilepsy arises from failure to distinguish between psychological concomitants of ictal and peri-ictal events, on the one hand, and the long-term effects of the occurrence of seizures on the psychological functioning/

functioning of the individual, on the other.

In this review, these are considered separately in each area of psychological function studied.

Evidence on psychological function in epilepsy is considered as the essential background to the central theme of this study - psychological function in the surgical treatment of epilepsy. This in turn requires to be evaluated in the light of knowledge of the effects of similar types of neurosurgical procedures in the treatment of disorders other than epilepsy.

The literature review takes the following order:

1. Specific aspects of <u>cognitive function</u>, related to (a) ictal and peri-ictal, (b) long-term effects of epilepsy, (c) surgical treatment, and (d) related neurosurgical procedures.

2. Specific aspects of <u>personality and behaviour</u> related to (a) ictal and peri-ictal, (b) long-term effects of epilepsy, (c) surgical treatment and (d) related neurosurgical procedures.

In this way it is hoped to complement rather than repeat already published reviews in the wider field of brain-behaviour relationships. Several comprehensive studies have become available recently, including two short texts in the Penguin Science of Behaviour series. Moyra Williams in "Brain Damage and the Mind" (1970) considers specific aspects of psychological function (e.g. perception and memory) and discusses some of the areas of the brain involved in these. Conversely, Edgar Miller in "Clinical Neuropsychology" (1972) considers various cortical areas of the brain and describes aspects of psychological function attributed to them. Moyra Williams' book has/

has been found a much more satisfactory source of reference, though whether because of the framework chosen or on account of the author's own extensive clinical experience is not certain. Cognitive function in epilepsy has been dealt with in two recent review papers by Stores (1971, 1973) and these have been found very useful.

(a) Ictal and peri-ictal cognitive function

An epileptic seizure has been defined as "any alteration of consciousness, perception or behaviour, not under voluntary control (and caused by the activation or inactivation of neurones, abnormal in degree or kind" (Pryse-Phillips, 1969). From this, one might anticipate a wealth of information to be gleaned in descriptive terms about psychological processes and associated neurophysiological data. Of course, not all seizures provide the opportunity for this type of investigation. The witness may be much more concerned with ensuring the patient's safety than with carrying out a study of psychological function. Nevertheless certain types of petit mal and psychomotor seizure do lend themselves to this type of study.

There are two main approaches to the investigation of the relationship between cognitive function and ongoing epileptic activity. One is to compare the performance of two or more groups, differentiated by the type of the seizure activity. This will be discussed later in Section 1a(iii).

The second approach is to obtain simultaneous recordings of EEG, and perfomance on some test of psychological function. The study may be designed to investigate changes in EEG record in certain situations, or while the patient participates in a certain activity. This is discussed in Section 1a(ii). Alternatively the study may be designed/

designed to <u>study changes in performance which are associated with the occurrence of certain paroxysmal patterns on EEG</u>.

<u>Section 1a(i)</u>

Stores (1973) summarises the evidence as follows, mainly related to the area of attention: "the more generalised, bilaterally synchronous and symmetrical the seizure discharge the more regular and organised the spike-wave complexes (as exemplified by the 3Hz pattern of classical petit mal) and the longer the duration of the burst, the greater the effect on attention."

One of the best known studies in this field is that of Mirsky and van Buren (1965), using a continuous performance task (in which subjects had to press a key whenever a particular letter or sequence of two letters appeared - rate of presentation one per second, over 10 to 20 minute periods). They found that performance in patients with non-focal "centrencephalic" epilepsy was impaired, and that the selective deficit which they showed persisted between attacks, presumably because of permanent disturbances in central subcortical structures.

The psychomotor seizure is defined partly in terms of disturbance of recording of ongoing events with subsequent amnesia, and in terms of disturbance of language function. Falconer (1963) reports that one third of a series of patients selected for temporal lobectomy showed paroxysmal dysphasia. Much of our information about disturbance of particular functions during psychomotor seizures has come not from spontaneous seizures, but from the effects of stimulation of the brain prior to or during the course of surgery. Penfield and others have reproduced typical psychomotor seizures in patients during stimulation of/

of temporal cortex.

They demonstrated bizarre memory and perceptual disturbances, varying with the area stimulated. One was described by Penfield as "psychical hallucinations" or "experiental seizures" - in which patients have recall of past experiences in vivid detail. These occur in about 10% of patients with temporal lobe epilepsy (Glaser, 1968). Ounsted (1966) describes the dreamlike tableau reported by one child who "saw Harry in a tree" - this related to a previous incident in the child's life when his cousin was in difficulties, having climbed a tree.

This type of experience is differentiated from "psychical illusions" or "interpretive illusions" - altered interpretations of present experience. These were also elicited on stimulation of lateral temporal areas, in one third of the patients studied, and were a more common occurrence in spontaneous seizures. Some of the experiences included in this category were:

(a) auditory illusions - distortions of volume and location of sounds;

(b) visual illusions - distortions of size and shape;

(c) body image distortions, and

(d) illusions of recognition - including the well known déjà vu and jamais vu phenomena.

The lateralising features in these have been emphasised by Glaser (1968). Penfield found auditory illusions were produced by bilateral stimulation, but visual illusions much more frequently from stimulation of the minor hemisphere, as were psychical hallucinations. Cole and Zangwill (1963) found déjà vu much more common in cases of temporal/

temporal lobe epilepsy with a non-dominant focus.

A third effect of stimulation, this time in the peri-amygdaloid areas, has been abrupt arrest of memory recording mechanisms (Penfield, 1958; Feindel, 1960; Chapman, 1958).

Jasper (1964), discussing these and other findings related to automatisms, places emphasis on "changes in patterns of discharge in response to incoming sensory information which must cause important distortions in information processing by the brain, even during periods between gross overt clinical attacks."

Section 1a(ii)

This leads to a consideration of the other half of this field of study - the effect of the subject's (or patient's) activity on the record produced by electroencephalographic methods. As early as 1936 Lennox stated that abnormal electrical activity was decreased during tasks requiring some degree of concentration. There have been some apparently contradictory findings but overall the evidence is suggestive of an optimal level, as Ounsted and Hutt (1964) suggest, circumstances which are neither too boring nor too stressful.

If certain activities "normalise" EEGs, then could these situations be exploited to regulate the electrical activity of the brain? This is an extremely exciting area just beginning to open up. A new rhythm detected over the sensorimotor area, during states of activation of the organism, has been discovered, characterised by 12-16 cycles per second synchronisation. After investigating the effect of this rhythm on suppression of a drug-induced convulsion in a cat, Sterman and Friar went on to investigate an operant method of conditioning of this rhythm using biofeedback techniques. They report the/

the successful application of these to one patient so far (Sterman and Friar, 1972).

Interest in the effects of activity on EEG is by no means restricted to epilepsy. The discovery of the expectancy wave - the contingent negative variation, first described by Walter (1964) has led to a great deal of experimentation on the effects of habituation, different levels of anxiety, types of psychiatric disturbance and many others (Becker , 1971). Studies of the electrical activity of the brain during different levels of consciousness have taken a range of forms - the study of patterns and stages of sleep (Oswald, 1966) and the recent findings of abnormal alpha rhythms during transcendental meditation (Banquet, 1973) to mention but two.

Hans Berger's original search was for some method of measuring the activities of the mind, not for a diagnostic tool in epileptic disorders. The diversity of situations which influence the brain's electrical activity and in which performance is influenced by paroxysmal disturbances, serves as a reminder that the study of ongoing epileptic activity during overt ictal events or in interictal periods, has still much information to yield about psychological function.

Section 1a(iii)

The psychological correlates of epileptic activity have also been investigated by comparing the performance on some task, of two groups each demonstrating a different type of epileptic activity.

Mirsky et al. (1960) compared the performance of those with temporal lobe lesions with a group with diffuse unlocalised or centrencephalic EEG abnormalities. The latter showed impairment on

a/

a test of sustained attention, while the former group showed impairment of memory function.

A group of patients with non-focal centrencephalic epilepsy were found by Kimura (1964) to be significantly slower on an alphabetical sorting task than patients with focal epilepsy. In particular those patients without myoclonic jerks were slowest on the sorting task and least accurate on a block tapping task.

In the 1950s, papers were published by psychologists on their work with patients in the two main units for surgical treatment (Montreal Neurological Institute and Guy's Maudsley Hospital, London). Brenda Milner (1954) and Meyer and Yates (1955) reported that patients with an epileptogenic focus of the dominant temporal lobe tended to be poorer on verbal than on non-verbal tasks, while there was less evidence of poorer performance on spatial perceptual items in patients with a non-dominant temporal lobe focus. Meyer reported that the patients with dominant temporal lobe lesions were significantly poorer than normal on a verbal learning task. Milner and Meyer are better known for their work on the effects of surgical lesions (covered in Section 1(c)).

For some researchers in this field, the prime interest is to utilise information about the site of the epileptogenic lesion and the deficit in psychological function. They hope to contribute to knowledge of localisation of function. In such studies, ablation and epileptogenic lesion are regarded alike, as providing a localised area of organic damage. Typical of these is a review of the literature by Dennerll (1964). He reported that the findings on cerebral localisation of cognitive function using psychological measures are not/

not completely consistent. "There is a growing body of evidence to support a relationship between various verbal abilities and the left hemisphere and somewhat more tentatively with the left temporal lobe and adjacent regions. These have been demonstrated in cases where speech is not markedly disturbed or where there are only very subtle dysphasic signs. Conversely various perceptuomotor or visuospatial abilities appear to be primarily related to the right hemisphere and especially to the right tempo-parietal area."

From his own results (using only non-surgical cases) he demonstrated that patients with right and left hemisphere dysfunction could be identified with considerable accuracy by use of regression weighted Wechsler scores.

Localisation of function is not a new field of study, nor restricted to epileptogenic areas. Broca, in 1861, postulated that the posterior third of the left inferior frontal gyrus is the "centre for the motor images of words" and 12 years later Wernicke (1873) expressed the view that the posterior third of the left superior temporal gyrus is the centre for the understanding of speech (Wortbegriff).

Fascinating as the conflicting evidence of functional localisation emerging over the subsequent 100 years has been, this is not the main topic under discussion currently. Comment on the Dennerll study is included because it exemplifies a problem. How far can his results and those quoted above (Milner, Meyer, Kimura, Mirsky and others) be attributed to ongoing epileptic activity, rather than to long-term effects of past epileptic activity?

<u>1(b) Long-term effects - cognitive function</u>

Many/

Many studies have been designed to investigate the long-term effects of epilepsy on psychological function. There is a tendency in such studies to consider measures of general intellectual level, rather than analysing specific cognitive processes as in many of the foregoing studies. Stores (1971) and writers in other fields of psychology have been critical of the global assessment in terms of I.Q., which it is claimed especially in children can be misleading, hiding specific deficits. Stores is particularly concerned with the implication of these in school and work situations. Where research into performance on specific tasks ameliorates conditions for the epileptic his argument is sound. Where a survey rather than an experiment is being carried out then it might be argued that measures of I.Q. provide more immediately usable information.

In 1917 Wallin stated that epilepsy is compatible with all levels of intellect from idiocy to genius - Julius Caesar, St. Paul and Dostoevsky are among names often quoted to indicate the above average effectiveness of some sufferers from epilepsy. The evidence accruing from longitudinal studies and surveys does not deny that those with epilepsy can be found throughout the range of intellectual capacity. However, it does tend to indicate a preponderance of cases at lower levels, and also that frequent severe seizures can slow down rate of intellectual development or can result in intellectual impairment - this distinction is important, since both can be reported as a "drop in I.Q." (Ounsted et al., 1966; Rodin, 1968; Livingston, 1973).

In many areas of human study attempts at evaluation of the long-term effects of some condition are hampered by the intervention of extraneous variables. Animal studies can provide some information

in/

in these areas. Recently there has been a great development of studies of experimental epilepsy in many species of non-human animal. Two papers, both presented at the Fifth European Symposium on Epilepsy (London, 1972), will be mentioned here. Plum (1972) has examined the effect of neonatal seizures on later development in rats. In a carefully controlled series of experiments he found that the stress of either daily single seizures or of a single two hour attack of status epilepticus in rats less than 10 days old, permanently reduces the number of cells and the weight of their brains compared to their littermates. Such animals are delayed in passing developmental milestones. Rats at a later stage of development (19 to 28 days old), subjected to the same electroconvulsive seizure regime, were not affected. Brain weight, cell number and cell size were no different from their littermates. Plum feels that this can be explained as the more mature brains being at a post-mitotic stage.

The second paper is by Meldrum (1973). He reported that intravenous injection of bicucilline, in adolescent baboons, led to severe generalised seizures. Some of these lasted 90-300 minutes. These produced neuronal change similar to that found in epileptic patients. He proposed that the damage results from interaction of a number of facts including abnormal metabolic activity of the brain, hyperpyrexia, hypoglycaemia, mild hypoxia and adrenal hypotension.

Age (or stage of development) at which seizures first occur had long been considered a critical variable determining effect of epileptic activity on intellectual level. Other variables considered important are pre-existing brain damage and the specific brain areas involved, frequency of seizures, severity of seizures and efficacy of medication/

medication. The establishing of something as apparently straightforward as age of onset has caused difficulty. There is dispute about whether the occurrence of one febrile convulsion in infancy should be taken as age of onset in an individual suffering no further seizures for perhaps a decade or longer.

Where onset of recurrent seizures at an early age has been considered, most evidence indicates a deleterious effect on subsequent intellectual development. E.A. Rodin in his book, "Prognosis of Patients with Epilepsy" (1968) devotes one chapter to reviewing the literature on intelligence and epilepsy and another to reporting his own findings in a series of 86 patients, 56 of whom were followed up after six years. The methodology of this study is of some interest. By utilising computer technology, formulae were developed that allow prediction of the likelihood of a patient achieving a long-term remission with outpatient treatment or becoming seizure-free during hospitalisation. In relation to intellectual function he concludes, "The fact that intelligence tends to decrease if the illness persists unchecked has to be taken into account. This is even more important when we recognise that the patients with an initially bright normal or superior intelligence quotient are more likely to suffer loss of intellectual functions."

The detail and scope of the variables utilised in his analysis are probably greater than those of any other study to date. It is not easy to digest the significance of his findings in one reading. Even if one is less confident than Rodin of the immediate clinical value of his predictive system, this work is extremely useful for reference purposes, both as a guide to the literature and to the author's/

author's extensive data on a moderately large number of cases.

Chaudry and Pond (1961) investigated the variables significant in determining degree of intellectual deterioration from a different angle. They used two carefully matched samples of children, both with some degree of brain damage. One group had shown intellectual and social deterioration. The two groups were compared in frequency of seizures, age of onset, effect of medication, age of and extent of presumptive brain damage, and associated behavioural problems. Their main findings were that frequency of seizures was very important, as was effectiveness of medication, but amount and duration of administration were not; nor were age of onset nor the presence of emotional or behaviour problems. The other finding of their study which is of great importance is that after years of apparent deterioration (intellectual and social) patients with improved seizure control could show improvement in scores on tests of intellectual function.

The importance of seizure frequency was emphasised by Blakemore et al. (1966). They found this factor was more closely related to impairment of verbal functioning than was neuropathology. Both this study and Chaudry and Pond's study refute the explanation of intellectual deficits in patients with frequent fits in terms of a direct relationship between frequency of fits and extent of brain damage.

In the introduction to this study a number of possible relationships between epilepsy and psychological deficit were put forward. One of these suggested that structural brain damage resulted from frequent seizures and that it was this permanent structural damage which then led to disturbance of psychological function. The two studies/

studies quoted above do not support this relationship as far as intellectual function is concerned.

Can one postulate that frequent but minor fits are likely to be disruptive to processes involved in attention, perception and registration - in other words, that frequent minor seizures may cause functional ineffectiveness and do not necessarily result in structural damage such as gliosis or atrophy? The major seizure or more so status epilepticus, on the other hand, with the additional hazard of trauma, is more likely to result in neuropathological changes in brain tissue.

Contrary to many of the above studies, Meyer and Jones (1957) in a small sample of patients selected for surgical treatment found neither age of onset nor seizure pattern important variables in cognitive test performance.

Many contradictory findings can be explained in terms of selection or bias of sample studied. Cases being considered for neurosurgical treatment are not a random sample of the population with epilepsy.

The converse of a study of intellectual impairment and epilepsy is a study of the prevalence of epilepsy among those who are intellectually impaired. One such sample are mentally retarded institutionalised patients. Eyman et al. (1970) report 31% of 23,000 such patients had a history of seizures or were active seizure patients. This cannot be taken as an estimate of the extent to which epilepsy causes intellectual deterioration to subnormal levels. It is well established that both epilepsy and mental retardation can be caused by the same organic insult, and that epilepsy and mental retardation coexist in the absence of any obvious predisposing factor.

However, since the ratio of 310 per 1,000, in a mentally retarded/

retarded sample, is so different from the 4 per 1,000 patients with epilepsy in the normal population, the point is of some interest.

In summarising his review of intelligence in epilepsy in 1968 Rodin makes the following six points:

"1. The group of epileptic patients can be divided into one of "pure epilepsy" and the other of "epilepsy associated with known brain damage of varying degrees." The "organic" group has lowered intelligence, but epilepsy is merely an added complication in these patients.

2. The "nonorganic" group has normal intelligence quotients, but there is a persistent suggestion that they tend to be shifted towards the low end of the normal range rather than being situated at the center.

3. Deterioration from a higher level appears to occur at times, but precise figures about the frequency of this phenomenon are not available due to the paucity of long-term longitudinal studies.

4. Follow-up studies which have been performed tend to show greater variability on test-retest measures than what would be expected from normal control groups.

5. The general trend for a group of patients tends to be in the downward direction, but the overall decrease in IQ points is usually not marked. In the individual patient one may observe either a decrease or an increase in IQ on follow-up examinations. This cannot always be related to the patient's current seizure state. Although it is uncommon for the IQ to increase in the presence of uncontrolled seizures, arrest of seizures can, but does not have to be, associated with an increase in IQ. A decrease of the IQ on one retest cannot be taken/

taken as evidence for permanent deterioration, because it can be offset by an equal increase in IQ points on subsequent re-evaluations.

6. There is a persistent suggestion that frequency of major seizures tends to be related to a decrease in intellectual function, and nearly all authors agree that an early onset of the illness is likely to be associated with decreased intelligence."

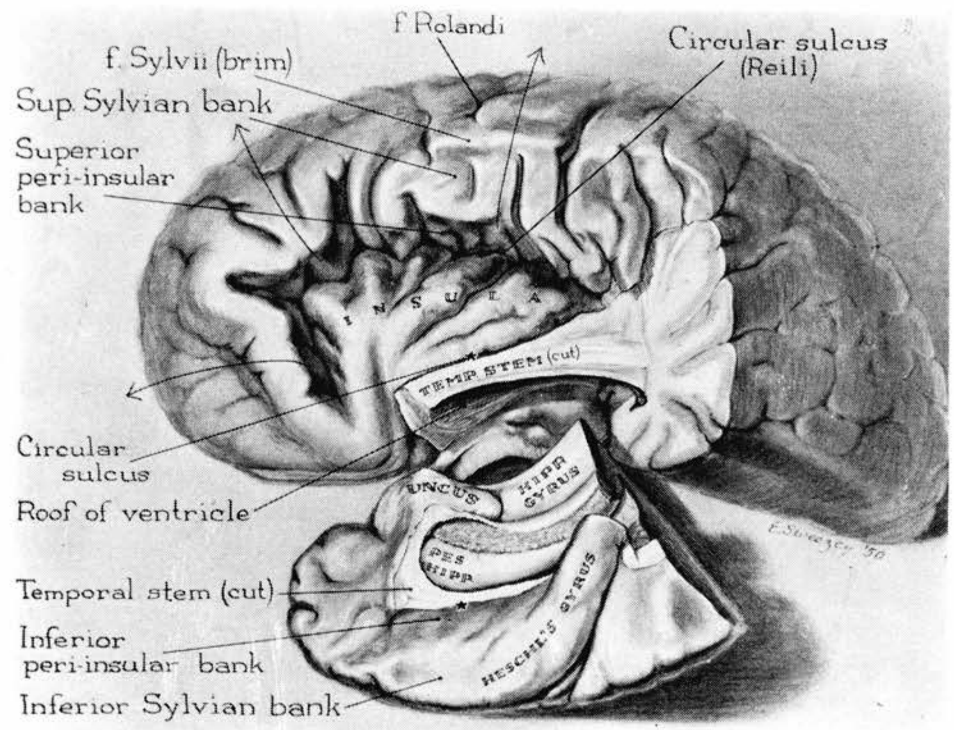
This evaluates succintly the evidence presented above.

1(c) Effects of surgical treatment

In the literature covered so far some polarisation of interests has been apparent; studies of memory and learning have been associated with temporal lobe epilepsy, and studies related to arousal and attention associated with subcortical structures implicated in non-focal epilepsy, termed "centrencephalic epilepsy" by some workers.

The effects on cognitive function of the surgical treatment of epilepsy have been studied largely from the data available on cases undergoing some form of unilateral excision of the temporal lobe. The literature on temporal lobe surgery is dominated by studies carried out by Penfield and Murray Falconer and their fellow workers. These two neurosurgeons have the largest series of cases undergoing standard operative procedures with adequate pre-operative assessment and long-term follow-up. Research publications have appeared almost annually from both centres over the past 20 years.

Neurosurgeons vary in the extent of their excisions. In one it is the anterior 5 cm. of the temporal lobe which are excised. Depth of excision varies. This affects how far mesial temporal structures are involved. In a series reprted by Green *et al* (1958) some cases included uncus and



Human brain with left temporal lobe cut and turned down. It shows the continuity of the superior surface of the lobe with the mesial surface, in the uncus, and with the cortex of the insula at the bottom of the circular sulcus

Fig.1.

hippocampus, others only uncus, and others no subcortical structures. Some of these structures are shown in Fig. 1 (Penfield & Jasper 1954).

If the aim of a particular study is to provide a comparison of the relative efficacy of surgery and medication, information about the precise extent of excision may not be required. The majority of studies, however, are interested in establishing the relationship between specific aspects of cognitive function and the amount and exact focus of cortical tissue removed. The emphasis ranges from studies monitoring cognitive performance to detect any undesirable side effects of surgery, to studies designed to contribute to theoretical formulations of localisation of function. This issue has been mentioned already in the preceding section.

Two studies, also mentioned previously (one by Milner and one by Meyer and Yates) are still regarded as key references in the psychological effects of temporal lobectomy. In 1958 Brenda Milner reported that unilateral excision of the speech dominant temporal lobe produces a temporary decline in verbal functions - she detailed particular sub-tests on the Wechsler-Bellevue Scale which showed post-operative deficits with less clearcut evidence of a temporary decline in performance on selected non-verbal tasks, such as picture completions, following non-dominant unilateral lobectomy. In the same paper Milner reports the drastic effects of bitemporal excision with loss of recent memory, inability to record and subsequently recall ongoing events. This did not improve with time and last year Milner reported that the patient (H.M) remains severely handicapped (Milner, 1972). Scoville and Milner's (1957) report of this case precluded any repetition of elective bitemporal surgery with involvement of hippocampal structures. Fortunately very few psychological reports are in an equally dramatic vein. Milner comments that the findings on over 100 cases suggest that:

(a) the left temporal lobe contributes to the understanding and retention of verbally expressed ideas,

(b) the right temporal lobe aids in rapid visual identification,

(c) the hippocampus and hippocampal gyrus (either separately or together) play a crucial role in the retention of new experience.

In the same symposium Ward Halstead also presented some results on psychological function following unilateral temporal lobectomy. He found postoperative improvement on most indicators (although this could still be at a lower than average level). No severe deficits were detected by him. His test data do not support an interpretation that important differences exist between the dominant and non-dominant temporal poles.

When such contradictory evidence is published one must question the variables involved in the different studies. The extent of excision, type of psychological tests, effect of medication, length of postoperative follow-up, are some of the important factors. Halstead's study found <u>no severe</u> deficits. Milner and others do not claim that the deficits which they found in unilateral cases are <u>severe</u>. In addition, general decline was only temporary.

Milner had published some very interesting results on a smaller number of patients using a wider battery of tests in 1954. She compared postoperative changes in 15 cases of left temporal lobectomy with 15 cases of right temporal lobectomy. The left lobectomy group did poorly on verbal memory tasks, including delayed recall of simple prose/

prose. The right lobectomy group showed significantly more errors on a non-verbal task - McGill Picture Anomalies Test. The drop of 16 points in Wechsler-Bellevue Verbal I.Q. noted immediately after left temporal lobectomy did not persist at follow-up, one year later. In 1962 Milner suggested that certain aspects of musical aptitude were also impaired after right temporal lobectomy. Kimura, whose investigations of different types of epilepsy have been reported previously, followed up Brenda Milner's pioneering study. One study (Kimura, 1961) entailed the use of non-verbal auditory stimuli presented dichotically. Temporal lobectomy on either side impaired recognition of material arriving at the ear contralateral to the ablation. In the visual modality Kimura (1963) found that after non-dominant temporal lobectomy patients were unable to recognise overlapping of recurrent nonsense figures or to count dots presented tachistoscopically. She interpreted this as indicating that the function of the non-dominant temporal lobe was perception of unfamiliar material, but Milner did not accept this. A joint study published in 1964 indicated that the right and left temporal lobes were selectively involved in the perception of non-verbal and verbal material respectively.

In 1968 Milner reported that following non-dominant temporal lobectomy patients showed a deficit in selecting photographs seen 1½ minutes earlier. Both perceptual and memory functions are involved. Agnosia for the human face - prosopagnosia - has been described (Gloning et al., 1966). It has been associated with parietal rather than temporal lobe lesions. Milner considers the deficits which she found to be more related to memory function.

In some other recent work Milner (1971) uses groups of

postoperative/

postoperative patients and compares the performance of these groups, rather than using each subject as his own control as in the earlier studies. Where numbers are adequate this may prove a more efficient way of collecting data, insofar as amassing pre- and post-operative cases is a very slow process. However, where the group is heterogeneous and small, the latter method is more satisfactory. Milner, comparing the performance of patients with frontal, parietal and temporal lobe lesions on a delayed response task, found distinct differences. Milner attributed the difficulty which was experienced by frontal lesion patients on this type of task to failure of concentration rather than to memory impairment.

Milner (1971) reports an unpublished study by Corsi further investigating differential effects of specific lesions. In this study patients with temporal lobe lesions of different extent were tested. Subjects were required to tap blocks in a given sequence. Unknown to the patient, the same sequence occurs every third trial. Corsi found that after right temporal lobectomy patients were impaired relative to the left temporal lobectomy patients. On an equivalent verbal task - repetition of sequences of digits - left temporal lobectomy patients were poorer. On both tasks the length of sequences was based on the patient's pre-tested abilities. A poor performance was represented by failure to learn the recurring sequence. Although data are available on only a limited number of cases, it seems that extent of lobectomy is important in determining degree of deficit on both tasks.

In parallel with the studies by psychologists working with Penfield's patients in Montreal, Murray Falconer's series of patients have/

have been investigated by psychologists following up the findings of Meyer and others. The London workers have tended to concentrate on the difficulties in verbal learning and memory, reported by Meyer and Yates (1955). This was based on a very small number of patients. Their conclusions about a specific learning deficit (demonstrated using New Word and Paired Associate Learning and Retention) were drawn from the significant differences in pre- and post-operative performance of six dominant temporal lobe cases. From their total sample of 18 patients they reported no general intellectual impairment, but a specific learning disability associated with dominant temporal lobe lesions, which may persist for at least a year. This was not found to be a function of level of intelligence, personality or postoperative changes in intellectual level. Meyer and Jones (1957) in a paper mainly concerned with laterality differences with epileptogenic lesions confirmed Meyer's earlier findings. They used tests of verbal and non-verbal material on a slightly larger group of 31 patients.

Blakemore et al. (1967) have analysed the variables involved in the given tasks. They questioned whether the deficit found is a learning deficit or a deficit in verbal abilities. They altered rate of presentation of the verbal material to be learned and found that the deficit could no longer be demonstrated. On the original task they found that the deficit persisted for 3-5 years (Meyer and Milner had both supposed it to be permanent). Blakemore found rate of recovery to be a function of age at the time of operation and of the persistence of fits postoperatively. Younger patients recover more quickly.

Blakemore's/

Blakemore's findings are extremely important in considering the functional plasticity of the brain. There is considerable evidence of greater plasticity in the early stages of development. Thus McFie (1969) states, "In cases of injury to either hemisphere at birth or in infancy the intellectual functions of both hemispheres are mediated by the undamaged hemisphere alone." He also stated that with cerebral injury beyond the first year (i.e. after speech development has begun), the relationship between side of lesion and abilities impaired begins to approximate to the adult pattern. Naughton (1961) found that special types of psychological function, especially language, can be exercised at a good level in the presence of lesions which would seriously disturb them if occurring in adulthood, if these lesions have been present since infancy.

There has been some dispute about how damaged an area has to be before its function is taken over by another area. Fedio and Mirsky (1969) in their study of cognitive function in children aged 6-14, with epilepsy, concluded that transfer of speech functions to the right hemisphere occurred <u>only</u> if "an early lesion encroaches directly on the classical language zone of the left hemisphere." They explain the impairment in verbal function found in cases of left hemisphere damage in this way.

Piercy (1964) hypothesises that "the infant brain is more equipotential for intellectual development than is the adult brain for the sustaining of intellectual skills. Therefore it could be that the infant's intellectual potential is more dependent on the integrity of the brain as a whole, and more unitary in function than are the abilities connoted by adult intelligence."

The/

The finding noted in the preceding section of this review, that the earlier the onset of seizures the greater the likely impairment of intellectual development, fits Piercy's suggestion.

Data available from a long-term follow-up of cases undergoing much more extensive surgical ablation than considered so far in this review are of importance in this context. Griffith and Davidson (1966) report on 12 cases of infantile hemiplegia and intractable epilepsy who were subjected to hemispherectomy. The report is based on a ten year follow-up. There were "worthwhile and significant long-term gains in intelligence in five of the 12 patients, slight but insignificant gains in six cases. No patient lost ground. Pre-operatively those with right hemisphere lesions were poorer on block design (WAIS subtest). These cases showed a postoperative improvement in language function. This was sufficient in one patient to enable him to obtain a university degree. Those with left hemisphere lesions were poorer pre-operatively on verbal comprehension (WAIS subtest), and postoperatively improved to above average level on a non-verbal test (block design) postoperatively (enabling one patient to become a skilled mechanic).

Another procedure applied to the treatment of intractable epilepsy to reduce spread to both hemispheres by abnormal electrical discharges, has been sectioning of the corpus callosum. This "split brain" technique is better known to psychologists than most neurosurgical procedures.

Earlier reports on the absence of callosal connections had indicated there were no resultant deficits in psychological function. Sperry and his colleagues have studied in great detail the few patients undergoing/

undergoing the procedure (Sperry et al., 1969). The type of deficits which they were able to elicit by subtle testing are particularly fascinating, in light of their comment that the 2-6 patients so studied showed very little evidence of "splitting" or "doubling" effects. One example will indicate the type of experimental set-up used. Two letters, numbers or pictures of objects were flashed simultaneously to the left and right visual fields. The patient denied seeing any but the right field stimulus. If the visual stimulus is being matched by touch with the <u>left</u> hand, the patient consistently selects the letter or other item that matches the <u>left</u> field stimulus. When asked to confirm verbally what item was selected by the <u>left</u> hand, the patient incorrectly names the stimulus in the right field.

In summary the findings were that there is a high order of mental activity in each of the disconnected hemispheres, an almost complete separation of gnostic processes, and that the right hemisphere was decidedly less proficient than the left.

Over the past three decades a method of destroying minute areas of brain tissue by inserting a probe into the brain, through a small hole bored in the skull, has been developed. Placement of the probe is determined by radiological methods of visualisation, utilising certain brain structures as landmarks. Such a stereotactic method in the human was pioneered by Spiegel and his fellow workers in 1947, first applied in the treatment of pain and emotional disturbance (Spiegel and Wycis, 1949) and then in other conditions, including Parkinsonism (Gillingham et al., 1960). Such methods are being applied to a widening range of neurosurgical problems, especially where subcortical areas are the targets for destruction. It has been argued (Falconer, 1973) that the use of

such/

such methods may result in failure to detect pathological tissue, the presence of which is not indicated by diagnostic techniques, but which is discovered by exposing the affected brain areas by subsequent neuropathological analysis. Falconer has argued that this is a particular hazard in the newer stereotactic approaches to mesial temporal structures in cases where behaviour disturbance may be associated with an epileptic disturbance. Falconer has found a high proportion of Ammon's horn sclerosis in his series of 100 patients, undergoing unilateral temporal lobectomy. This would remain undetected by a neurosurgeon destroying tissue stereotactically rather than by open excision.

The majority of studies in this area are more concerned with evaluating postoperative change in behavioural disturbance than in cognitive function. The patients are often not amenable to standard methods of psychological investigation. Despite the difficulties Anderson (1972) carried out a very interesting study of specific aspects of learning function before and after stereotactic amygdalotomy. She found a postoperative deficit in the registration phase of learning. This persisted one year postoperatively. Douglas and Pribram (1966) provide a model for investigation of the effects of lesions in the amygdala and hippocampus on various aspects of learning and memory. Differential functions are attributed to these two limbic structures, based on their studies in monkeys.

Other studies have reported improvement in general intellectual level, often attributed to decrease in disturbed behaviour with subsequent increase in attention (Heimburger et al., 1966; Narabayashi et al., 1963).

One/

One study which it was anticipated would be of particular value to the present study, was that by Horowitz et al. (1970) in which patients were tested before and after (a) implantation of electrodes in the temporal lobes, (b) making of stereotactic lesions, (c) unilateral excision of temporal lobe. It is unfortunate that the results obtained from this study are difficult to interpret. They do not seem to fit readily with the model subsequently presented by the authors, in terms of simultaneous and sequential organisation functions of cortical and subcortical brain areas. They do not provide adequately detailed information about the site of the implanted electrodes or of the stereotactic lesions, for comparison to be made with other studies. The main findings on psychological testing were of marked memory impairment (this was noted clinically as well as on Wechsler Memory Scale), following implantation of electrodes "in or near temporal lobes." There was little change in general intellectual level following any of the three procedures. Following temporal lobectomy, there was a decline in score on the Porteus Maze Test (results are reported for eleven non-dominant and four dominant temporal lobe cases).

Stereotactic approaches in epilepsy have not been limited to mesial temporal structures, where the occurrence of clinical seizures may be relatively unimportant, contrasted with the marked behavioural abnormality. The possibility of destroying minute quantities of tissue in central brain structures, held to be involved in the transmission of epileptic discharges in the type of epilepsy where no cortical focus has been found, has been considered only in recent years. In 1965, in a very interesting paper entitled "The thalamus and/

and epilepsy" Denis Williams concluded that "there is physiological justification for further study of the effect of stereotactic lesions in the median thalamic nuclei in patients whose general epilepsy cannot be controlled in any other way." Denis Williams' view that the term centrencephalic epilepsy is a misnomer, has already been discussed. He is concerned with the role of thalamic reticular structures in the development and diffuse spread of the general discharge, which is held to have its origin in the other brain areas.

Jinnai (1963) in Japan and Mullan (1967) in Chicago have published preliminary results in this field but without any detailed report of psychological assessments carried out. Mullan does report a slight decrease in the speed of finger movement in two patients and a complaint of memory impairment in one patient which was not substantiated by formal testing.

1(d) Related neurosurgical procedures

It is particularly important therefore to consider the evidence available from other sources about the effects on cognitive function of such stereotactic lesions in central brain areas - thalamus and other diencephalic structures. As Edgar Miller (1972) points out, neuropsychological studies have neglected subcortical structures, the majority of published studies being concerned with lesions in major cortical areas. The work of Riklan and Levita (1969, 1970) on psychological correlates of subcortical structures is probably the best known. On a lesser scale than for cortical lesions similar controversies exist. How far can function be localised? Is laterality important? What is the explanation of short and longer term effects of deficits postoperatively? An extreme standpoint on the localisation/

localisation issue is held by Andy and Jurko. They have for a number of years been reporting findings of a very specific nature, associated with discrete lesions. The use of stereotactic methods enables target zones to be specified in millimetres. In their latest publication (1973), they plot the exact sites at which particular test deficits were found to occur. They conclude that when lesions were restricted to the centrum medianum of thalamus, few deficits were detected. Outside this nucleus - lesions in ventralis posterior, pulvinar or ventralis oralis produced a wider range of deficits. The more complex skills tested revealed more impairment and the deficits were long-lasting. Deficits were noted on Digit Symbol and Similarities (two subtests of the WAIS) and on the Graham Kendall Memory for Designs Test. Neither Picture Completion, Block Design (WAIS), nor Phi Phenomenon, showed much change postoperatively. Except on the Bender Gestalt (a perceptual task involving copying given patterns) on which right thalamotomy produced greater deficits, no test indicated a laterality effect. Andy and Jurko interpret the digit symbol and similarities subtests of the WAIS as involving more complex cognitive skills than the subtests on which no differences occurred. It is difficult to locate their reference to this in the Wechsler Manual (Wechsler, 1955). McFie in his review (1969) of the effect of brain lesions on psychological function, concluded that the Digit Symbol subtest of the WAIS was subject to impairment by lesions in any area of the brain, while other subtests were selectively impaired; for example, he reports that there is a decline on the similarities subtest, particularly associated with left temporal lobe lesions.

While Andy and Jurko's work is based on a large series of patients/

patients (60-90 patients on different tests), the specificity of their findings must be treated with a little scepticism. The technical sophistication of stereotactic procedures must not blind one to the possibilities of some variation in the exact siting and extent of the lesion. Radiological verification is possible, but any method other than autopsy does involve some degree of estimation.

There is little support from other studies for the claim of <u>differential</u> effects of specific thalamic nuclei on cognitive function. There is, however, some support for the effect of lesions in thalamus and adjacent structures on a range of psychological functions. Hicks and Birren (1970), considering evidence on aging and brain damage (from performance on tasks such as reaction time), suggest that damage or dysfunction of basal ganglia may be a basis for the psychomotor slowness observed in human and animal subjects.

Siegfried and Perret (1969) found little short or long term effect on WAIS but a significant long term decline on three learning and memory tasks following unilateral thalamotomy. They concluded that any temporary decline which does occur, results either from inhibition, or that other structures take over the functions originally mediated by the destroyed area. They found unilateral thalamotomy to affect the storage of information processes as such and that this is independent of the type of information to be stored and independent of the side of the lesion.

Orchinik (1962), reporting a series of cases who had undergone dorsomedial thalamotomy for the relief of pain or psychiatric disturbance, found only short term effects on memory, both on the acquisition of new material and in the retention of old material. These were/

were bilateral lesions. Further support for the role of the thalamus in memory processes is derived from a study by Ojemann and Ward (1971) who found that stimulation of left ventrolateral nucleus of thalamus produced memory and speech disturbances.

Riklan and Levita reported in 1969 that slight impairment of language function was associated with left thalamic lesions and with second-sided lesions irrespective of laterality.

In Edinburgh a large series of cases of Parkinsonism undergoing stereotactic surgery, with thalamic and pallidal target sites, has built up (Gillingham et al., 1960, 1966). Disturbance in speech function was the subject of a separate report (Allan et al., 1966) which reported some evidence of dysphasic disturbance associated with left ventrolateral thalamic lesions.

Psychological function was assessed using Raven's Progressive Matrices, Mill Hill Vocabulary Scale, Graham Kendall Memory for Designs, Sentence Repetition and Rorschach Inkblot Technique. The results of pre- and post-operative testing of a group of 60 patients (Naughton, personal communication) indicated only very slight changes in mean score. On the vocabulary test, the only two cases whose performance showed a significant decline had lesions outwith the normal target sites. On non-verbal reasoning, in the only case showing a significant decline, there was intellectual deterioration preoperatively. This case also showed postoperative decline on design reproduction, as did a case with postoperative confusional state. Psychometric studies were found useful in prognosis and it was reported (Gillingham et al., 1960) that the only absolute contraindication for surgery was definite evidence of increasing mental confusion/

confusion of a moderately severe degree (not dependent on toxic reaction to drugs).

The use of psychological assessment in studies such as the Edinburgh one above is in monitoring the patient's condition. This is in contrast with studies such as that of Andy and Jurko, designed to investigate localisation of function.

Riklan and Levita are concerned about a theoretical framework with which to consider brain function. They invoke concepts of activation and direction. One of their clearest statements of their standpoint is in their objection to the dichotomy approach. They point to three dichotomies: (a) cortical/subcortical, (b) left/right, and (c) specific/nonspecific effects of brain function. They stress the need for a theoretical model based on inter-relationships between various brain structures and between aspects of psychological function. Luria (1973) also stresses the need to consider such inter-relationships.

Ojemann (1968) reviewed the evidence of the effect of brain lesions on memory in man. He covers many aspects of memory function and found some brain structures more involved in specific types of memory. However, a glance through the complete range of brain structures implicated in some way serves as a warning against a "blinkered approach" - which can lead to the assumption that a structure found <u>necessary</u> for a particular function is <u>sufficient</u> for that function. Neither stimulation nor ablation studies permit valid conclusions about the function of specific brain structures (Feindel, 1960; Jasper, 1960; Gregory, 1961; Weiskrantz, 1968). These authors point to the <u>logical</u> fallacy of using negative evidence (e.g. loss of/

of function post-ablation), to attribute specific functions to specific brain areas.

Summary of Section 1

What conclusions can be drawn at this stage from the evidence presented on cognitive function in surgical treatment of epilepsy? It appears that there is a similarity between deficits detected in specific brain areas as a result of an epileptogenic lesion in that area, and deficits occurring following a surgical lesion in the same site (stereotactic coagulation or excision) with some evidence that destruction of the site of the focus will emphasise pre-existing deficits. However, surgical intervention has also been found to result in improvement in overall intellectual level, interpreted as increased effectiveness of the remaining brain tissue.

There are discrepant views about the determinants of impairment in psychological function in cases of epilepsy, but it does appear that the earlier the onset the more damaging the effects; the earlier the treatment the better the results.

In earlier studies little emphasis was placed on the role of subcortical structures in cognitive function. Now, diencephalic structures have been implicated in rate of reacting, language, learning and memory.

Evidence has accrued from "centrencephalic" epileptic processes, and from the effect of neurosurgical lesions in these structures, for a variety of symptoms but not as yet where the lesion is designed to alleviate epilepsy.

The functions of limbic structures in orienting, learning and memory have been studied extensively in animals (Eleftheriou, 1972) and/

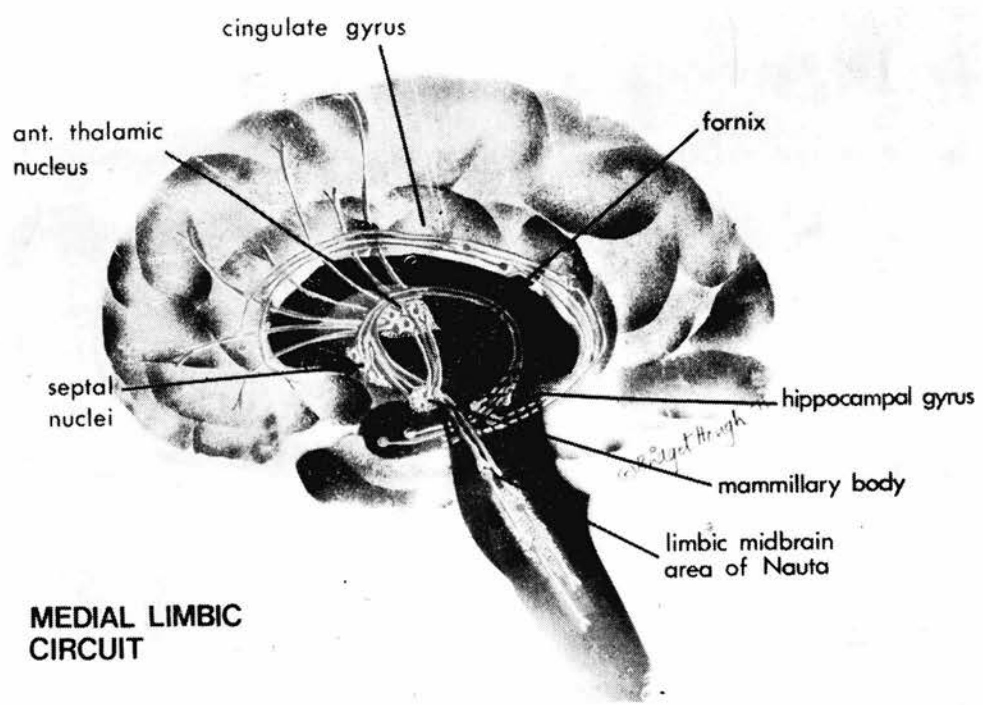
and some evidence has accrued from human cases of ablation including mesial temporal structures and pathological abnormality of limbic structures. One such structure apparently very important in the animal's adaptation to the environment is the amygdala. The role of this structure in cognitive function in man has been little investigated.

From studies of cortical areas, it is now accepted that there is a certain extent of localisation of function with little disagreement for example about the significance of the hippocampus in memory, or of the dominant temporal lobe in language function. There is less agreement about specific functions in the processing of non-verbal material, mediated by the non-dominant temporal lobe and about lateralising features in other cortical or subcortical structures.

The (i) logical arguments and (ii) research findings plus (iii) a quest for a theoretical framework based on inter-relationships and systems rather than structures and traditional psychological functions, indicate the likely direction of future developments.

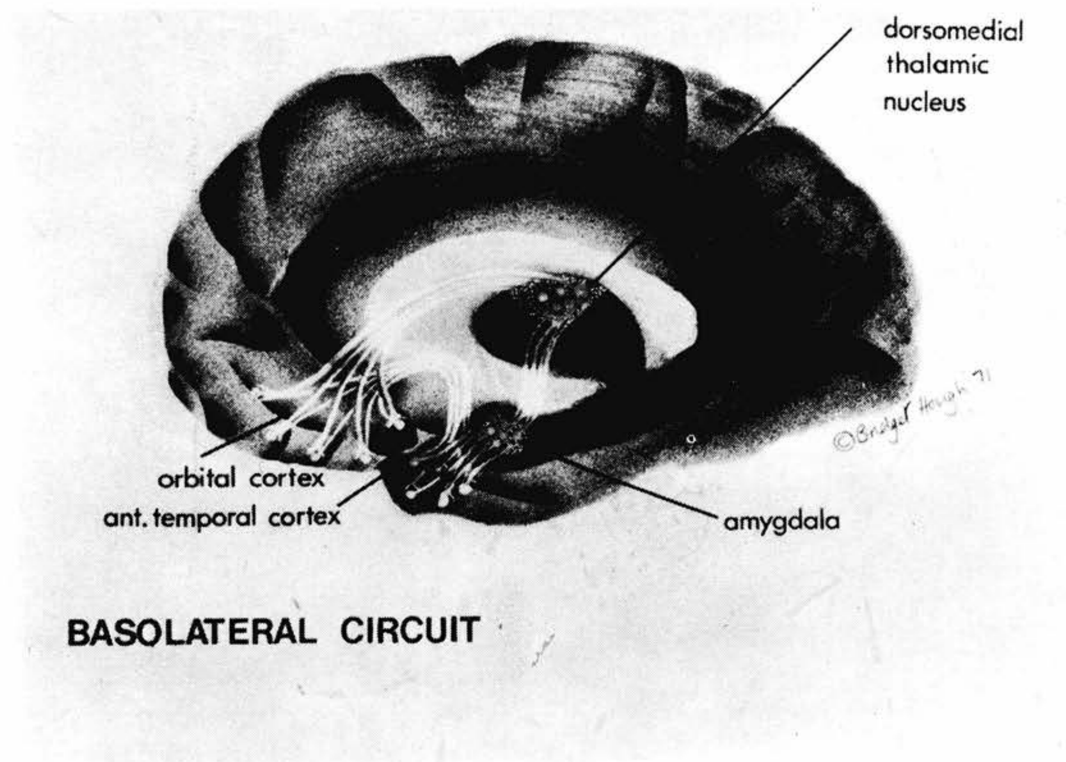
2. Personality and Behaviour

If psychologists have found some difficulty in accepting a correlation between cognitive function and specific structures in the brain, they have found it much more difficult to consider a structural basis of personality or "the mechanism of emotion" sought by Papez (1937). The 'Papez Circuit' includes the hypothalamus, hippocampus, cingulum, fornix, mamillary bodies, anterior thalamic nuclei and the interconnections between these. Various terms have been used for this group of structures - rhinencephalon, visceral brain (Maclean, 1955), 'emotional brain' (Williams, 1968). The structures bordering the ventricular system had been called a "limbic lobe" by Broca. There are many interpretations of what constitutes the limbic lobe or limbic system. Ranson (1959) considers the concept should be abandoned, with the structures involved being described as within frontal, temporal or parietal lobe as appropriate. Nauta (1973) points out that demonstrable functional and anatomical inter-relationship will determine how inclusive the term should be. Livingston and Escobar (1973) suggest that the limbic system should be considered as two circuits - a medial one (based on the Papez Circuit) - concerned with activity in the reticular core. The second circuit they call basolateral - which includes cortex of orbital, frontal insular and anterior temporal areas, together with connections with the amygdala and dorsomedial thalamic nuclei. This circuit is concerned through its temporal connections with the activities of sensory-receptive and interpretive cortex. These two circuits are shown in Figs. 2 and 3. There is no direct connection between the two, but Livingston and Escobar suggest that/



The medial limbic circuit.

Fig.2.



The basolateral limbic circuit.

Fig.3.

that normal behaviour is dependent on the maintenance of a balance between the two.

Certain limbic structures, particularly the amygdala, are known to be electrically highly excitable, with lowered threshold for stimulation and seizure discharge (Gloor, 1960; Stevens, 1969). It was Hughlings Jackson who last century recognised that seizure discharge originating from this area produced what is now known as "psychomotor epilepsy."

In earlier writings Jackson (1879) had indicated that emotional experiences could form an integrated part of an epileptic attack. He described feelings of fear associated with an epigastric aura.

Thus a triangular relationship is suggested:

Emotion

Limbic system

Epilepsy

In considering this, and the broader aspects of personality and behaviour in epilepsy it is proposed to use the same framework as in the preceding section; i.e. to consider first ictal and peri-ictal events, followed by a consideration of the long term effects of epilepsy, the effects of surgery and finally the effects of related neurosurgical procedures in man and animals.

2(a) Ictal and peri-ictal effects

Falconer and Taylor (1970) record changes in mood, fear or pleasure, feelings of derealisation, depersonalisation, and perceptual illusions as part of the temporal lobe seizure, and that peri-ictal events include outbursts of violence, occasional sexual misdemeanours and relatively brief fugue-like wanderings. They categorise the salient/

salient features of psychomotor attacks under three headings:

(i) objective concomitants (including speech disturbances and motor activity);

(ii) subjective concomitants (including somatic, emotional, perceptual and memory aspects);

(iii) automatisms (reserved for snatches of purposeful behaviour, such as searching, undressing, rather than the lip-smacking and so on sometimes included in this heading).

Ictal emotions were the subject of a detailed study by Weil (1959). Of 132 patients with symptomatic temporal lobe seizures, 28 (21%) experienced ictal emotions. Fourteen patients experienced predominantly ictal depression and 14 predominantly ictal fear. Weil found ictal fear to be short-lived, frequently experienced as part of the aura, preceding the "full-blown" temporal lobe seizure. Ictal depression was of longer duration, either inter-ictal, or as an isolated expression of an epileptic after-discharge, explained in terms of subclinical hippocampal-amygdaloid-temporal lobe epilepsy.

The preponderance of negative emotions reported by Weil is reflected by other surveys of the clinical pattern of seizures. Currie (1971), Williams (1956) and Stevens (1957) reported pleasurable emotions in only a very small proportion of cases. Penfield and Jasper (1954) noted the absence of pleasurable sensations from stimulation of temporal structures, often reproducing the typical seizure pattern in an individual patient. There is some evidence that amygdaloid stimulation in rats is a rewarding experience (Gloor, 1960).

There are strongly divergent opinions about the association between epilepsy and aggression. This topic will recur throughout the/

the remainder of this review. At this point concern is about ictal and peri-ictal events.

Neither Lord Brain (1962) nor Falconer (1970) include rage or anger as a subjective ictal emotion, but it is experienced by 15 - 20% of patients with ictal emotions (Weil, 1959; Currie et al., 1971). However, this represents only a very small proportion of the total sample of cases of epilepsy in each of these studies (e.g. 5 of 132 cases in Weil's study).

According to Poeck (1968) one type of pathological rage in man is demonstrated by both seizure manifestations and inter-ictal phenomena in psychomotor epilepsy, consisting in "directed attacks of unrestricted rage."

Blumer (1973) argues that the co-ordinated and relatively goal-directed performance, with intact consciousness and memory sets this type of paroxysmal behaviour apart from the seizure. He and Gloor (1967) have expressed the view that anger or rage as a psychomotor seizure event is virtually unknown.

Ounsted et al. (1966) found 36 cases who manifested what he labels as "catastrophic rage" in his series of 100 patients with temporal lobe epilepsy. He discusses this in terms of Flynn's findings (1963) of aggression in cats following hypothalamic stimulation. However, Ounsted concludes that the rage outbursts are characteristic of a particular form of brain damage rather than an integral part of the epilepsies.

A different standpoint is taken by Sweet et al. (1969). They consider that the directed attack of the temporal lobe epileptic who gets involved in senseless fights can be regarded as a complex kind of/

of convulsive seizure.

They present evidence from a patient with electrodes implanted in both temporal lobes. Telemetric stimulation of hippocampal and amygdaloid electrodes produced progressive clinical and electrical abnormalities culminating in violent behaviour. The authors consider the evidence sufficient to classify these manifestations (pounding fists against a wall and smashing a guitar) as another form of the patient's epilepsy.

They suggest further that if a patient with psychomotor epilepsy may assault "senselessly" as a part of the epileptic attack, then it may be possible that some others who attack impulsively have this as the only symptom of focal brain disease.

S. Livingston (1973) considers that the label of epilepsy should not be used in cases where the only evidence is temper tantrums or rages, but only if EEG abnormalities have been demonstrated to occur simultaneously with the emotional reaction.

This is a very stringent requirement. It becomes of particular importance where the rage or aggressive outburst has resulted in violent assault and the question of criminal responsibility arises. Falconer and Taylor (1970) support Alström's view (1950) that crimes of violence are not a significant part of ictal behaviour. In Falconer's experience of 250 temporal lobectomies no patient has ever been charged with a crime performed during or immediately after a seizure.

However, murderers as a group do contain a higher proportion of epileptics than the normal population (Hill and Pond, 1952). Gunn and Fenton (1969) found the prevalence of epilepsy in 20 penal establishments/

establishments in England and Wales to be 7.1 per 1,000 (compared with 4 per 1,000 in the normal population).

Denis Williams (1969) reviewed the EEG findings in 333 of the more than 1,250 prisoners referred to him - all either awaiting trial or convicted of a crime involving bodily violence. It was found that 49.5% of the sample had abnormal EEG records (compared with 12% in the normal population). Of greater importance, Williams considered his finding that among the habitual aggressives (206), 65% had abnormal EEGs, while among those who had committed a solitary crime of violence (127), only 24% had abnormal EEGs. Further analysis of the data, excluding cases with brain damage, epilepsy, head injury and mental subnormality, indicated that in the group of 68 who had committed a solitary crime there was only 12% EEG abnormality, while among the 130 habitual aggressives 56.9% had abnormal EEGs.

These findings cannot be accounted for by Ounsted's explanation of his "catastrophic rages", in terms of brain damage co-existent with epilepsy. Williams considers that there is much indirect evidence that the disorders arose in consequence of limbic, diencephalic and mesencephalic dysfunction as postulated by Gloor (1968), which occurred at an early stage in the individual's maturation.

Williams is not providing evidence for "ictal crime", although he does comment that the locus of the EEG abnormality found in a high proportion of cases (anterior temporal and lateral frontal) was similar to that in temporal lobe epilepsy. He does not argue that the violent behaviour should be regarded as a seizure. Weil's (1959) concept of subclinical disturbance in limbic structures as an explanation of long lasting ictal depression is rather similar to Williams' explanation/

explanation above. Blumer (1973) indicates a low threshold for anger and rage reactions in temporal lobe epilepsy, related to subclinical seizure activity in the limbic system. Similarly Gloor (1960) talks of "a continuous state of subictal irritation by the focus" as the cause of the explosive anger often provoked by trifling events in psychomotor patients.

In addition to such inter-ictal disturbances, irritability as a prolonged psychic aura may precede an attack by hours or days. There is also some evidence of aggressive behaviour in the post-ictal phase of confusion or excitement. This tends to arise from hallucinatory experiences or if the patient is interfered with by others (Brain, 1962; Falconer and Taylor, 1970; S. Livingston, 1973).

Thus it seems there is evidence of:

(1) ictal rage, experienced by a <u>minority</u> of cases,

(2) aggressive behaviour occasionally precipitated during ictal or post-ictal confusional states.

Much more common is:

(3) pre-ictal irritability, (4) inter-ictal irritability, which may occasionally lead to violence on minimal provocation.	) Not restricted to temporal lobe epilepsy

There is also:

(5) a high incidence of EEG abnormality (implicating dysfunction of limbic structures) among habitually violent criminals, both with and without clinical epileptic seizures.

Despite this evidence there is considerable reluctance to label temper tantrums or violent, assaultive behaviour as epilepsy, in the absence/

absence of corroborative evidence, of alteration of consciousness, concurrently abnormal electrical activity, or other evidence of seizure activity in an individual patient.

To look on disordered social behaviour as the end result of the disturbed activity of cerebral cortex may be misleading (Williams, 1968). Here Williams is again concerned with the relationship between brain stem alerting structures and neocortical activity, emphasising the role of the former in sensory processes (alertness and vigilance). He suggests that the aggressive psychopath acts wrongly because he perceives inefficiently.

The role of the limbic system in attentional processes in man and animals has already been mentioned (Douglas and Pribram, 1966; K. Livingston, 1973). The importance of such processes in the "defence - flight - fight" pattern of responses has been discussed (Stevens, 1957; Kaada, 1967). Attempts have been made to link the cognitive, affective and effective role of limbic structures.

Williams has drawn attention to the importance of perceptual processes in the subsequent aggressive response, but the significance of distorted perceptions in other types of abnormal behaviour has been much more readily recognised.

Glaser (1968) classifies the perceptual disorders in limbic epilepsy as:

(1) Somatic (including olfactory, visual (illusions and deja vu), hallucinations and disturbances of bodily image).

(2) Visceral (including gastric, hunger, pharyngeal, genital).

Some types of perceptual distortion, occurring as an integral part of the psychomotor seizure and following stimulation of the temporal/

temporal lobes in epilepsy, have already been described - depersonalisation, derealisation, and Penfield's psychical hallucinations and illusions.

Such disturbances are commonly described symptoms of psychotic disturbance. It has been claimed that there is hardly one of the most characteristic symptoms of schizophrenia, of a positive kind, which may not be experienced as an aural phenomenon in temporal lobe epilepsy. In addition 25% of schizophrenics have epileptiform EEGs (Symonds, 1962). Exploration of the relationship between epilepsy and psychosis has an interesting history. This is well documented by Flor-Henry (1969). Briefly - Kraepelin (1910) believed in an association between the two, while Meduna (1937) considered the two antagonistic and thus developed electroconvulsive therapy for schizophrenia and then for depressive psychoses. At about this time the antagonism theory fell into disfavour and evidence accumulated that on the contrary, certain forms of epilepsy predisposed to schizophrenia rather than protecting against it. The schizophrenia-like psychosis associated with temporal lobe epilepsy has gradually been defined. The two most detailed recent studies, somewhat conflicting in their conclusions, are those of Slater et al. (1963) and Flor-Henry (1969).

The existence of a temporal relationship between psychological function and the seizure has been discussed in connection with cognitive function and aggressive and other emotional responses. An inverse relationship has been found between seizures and psychotic episodes in individual patients (Landolt, 1953; Dongier, 1960) and in two matched groups (Flor-Henry, 1969). Glaser (1964) did not substantiate/

substantiate this. Glaser concludes that inter-ictal personality and behaviour disturbances may be due at least in part to subictal cerebral excitation.

Glaser also reports that certain features of psychomotor seizure appear to predispose to later psychotic disturbance. This turns the discussion from peri-ictal events to a consideration of the long term effects of epilepsy.

2(b) Long term effects of epilepsy on personality and behaviour

Both the papers of Slater et al. (1963) and of Flor-Henry (1969) on "Psychosis and Epilepsy" are complex in their reasoning and in methodology. The former is more equivocal in its conclusions. The decisive findings reported by the latter have been widely acclaimed. Perhaps it is the degree of certainty with which the conclusions are stated which creates some suspicion, in what is such a complex topic.

Slater and Baird (1963) consider a number of possible interpretations of the results obtained from a study of 69 patients (1) with a diagnosis of epilepsy supported by EEG or unequivocal clinical evidence, and (2) diagnosis of schizophrenia. The authors concluded that it would not be possible to diagnose these patients, on psychological symptomatology alone, as suffering from anything other than a schizophrenic psychosis, although in discussion they do accept Pond's (1957) finding of the preservation of affectiveness and responsiveness, unusual in schizophrenia. Thus they speak of the "schizophrenia-like" psychoses of epilepsy. They consider it more probable that it is the cause of the epilepsy which is the cause of the psychosis, rather than that epileptic fits themselves cause the psychosis. In coming to this conclusion, they tend to reject Pond's hypothesis that "years of attacks of/

of clouded consciousness might lead to a confusion of reality and autistic thinking and experience." Instead they favour a physiogenic basis, such as suggested by Symonds (1962). This is similar to Glaser's view stated above of "subictal excitation." Symonds comments that it is not the loss of neurons in the temporal lobe which is responsible for the psychosis, but the disorderly activity of those that remain (which is also a likely cause of seizures). But Slater et al. (1963) had found evidence of atrophy in a high proportion of cases (37 of the 56 on whom AEG examinations were done). They reconcile this with Symonds' hypothesis by suggesting that it is not dead cells but dying ones which cause trouble. They go further to suggest the nuclear schizophrenias are themselves organic psychoses, affecting the same functional systems of the brain. Their final statement is that "it is as a mock-up of the genuine schizophrenic that the schizophrenic-like epileptic is worth special study."

There is no disagreement between the Slater study and Flor-Henry in the significance of temporal lobe epilepsy. In three quarters of Slater's cases a temporal lobe origin was found. Flor-Henry's 50 cases were selected from the archives, based on a diagnosis of temporal lobe epilepsy, with a history of classification as psychotic. It is important to note that the two samples are not directly comparable. Slater et al. restricted the psychotic category to "schizophrenia" while Flor-Henry included all cases of psychoses, but restricted his series to epilepsy of definite temporal lobe origin. The psychotic cases are categorised as (1) schizophrenic, (2) schizo-affective (mixed), (3) manic depressive, and (4) confusional. Emphasis is placed on the design of the study, which is a retrospective one/

one, with data collected from case records. Fifty psychotic cases with temporal lobe epilepsy are matched with 50 non-psychotic epileptic controls, and the groups compared on 71 variables. Flor-Henry concludes that, contrary to Slater, he considered the epileptic psychoses as fundamentally related to the epileptic process, rather than non-specific psychosis resulting from brain damage. His series certainly contains a far smaller proportion of abnormal findings reported on AEG (only 12 of 85 cases), with greatest incidence in confusional and least in manic depressive groups. The numbers in both these groups are however quite small.

In a study of this type where methodology in terms of matching groups is described with care, it is readily assumed that other critical variables are capable of accurate evaluation. One of the main arguments rests on the evidence of a difference in fit frequency between psychotic and control groups. It occurs to anyone familiar with the manifestations of temporal lobe epilepsy, that such events are very capable of inaccurate documentation in case records. What evidence is there, that either psychomotor or minor seizures would be as readily observed and recorded in a psychiatric as in a neurological or neurosurgical population? Furthermore, the similarity between the disturbance of function in schizophrenia and the psychomotor seizure has already been noted.

In categorising patients according to lateralising features on EEG, no mention is made of the consistency over time of the EEG records, or whether only one record was considered. If the latter, then it seems rather hazardous to place such weight on these findings. One of the main conclusions of the study is that temporal lobe epilepsy of/

of the dominant hemisphere predisposes to psychotic manifestations; in addition, epilepsy of the non-dominant temporal lobe is associated with manic depressive, and of the dominant temporal lobe with schizophrenic, disturbances. In the text of the paper, however, it is indicated that the number of cases in the manic depressive category (9) makes it too small for the systematic statistical analysis applied to much of the data, and that only trends can be considered. Flor-Henry is not criticised for pointing to a trend. However to include, in his summary, a definitive statement, seems to misrepresent the evidence. It is regarded as much more serious when, in a paper presented at a psychosurgical conference, he cites such evidence as one of "an increasing number of investigations in recent years (which) converge to suggest that, to a remarkable degree, the psychiatric syndromes can be correlated with definite cerebral regions" (Flor-Henry, 1973). In this paper he provides a general model of psychiatric symptomatology based on the concept of temporal limbic instability.

In many ways, such a neat model is very attractive as a beacon in a fog. However, the above arguments indicate the rather shaky foundations on which the beacon is built.

The less definitive conclusions of Slater seem more realistic at a stage in this complex study when it may be essential to avoid the construction of rigid explanations.

It might be considered that the preceding topic has been dwelt on for an undue length of time, since psychosis occurs in only a minority of cases and is peripheral to the present study. Nevertheless, the two papers dealt with in detail have received considerable attention, especially in psychiatric circles. Furthermore, some of the/

the above arguments are central to the whole topic of epilepsy, personality and behaviour.

In addition to mood disturbances, aggressive behaviour and psychosis, a further syndrome - this time observed in children - is often linked with epilepsy, again specifically temporal lobe epilepsy. The hyperkinetic syndrome, as described by Ounsted (1955, 1966) is characterised by intense overactivity throughout the whole of the waking day, a shortened attention span, a prevailing mood of euphoria which may be punctuated by catastrophic outbursts of rage. Shyness and fear often disappear and the children are inattentive to danger. Males are predominantly affected - the syndrome usually dies out before puberty.

In a series of 100 children with temporal lobe epilepsy, Ounsted et al. (1966) identified the syndrome in 26 (20 boys, 6 girls). Masland (1966) estimated a 5-10% incidence of the syndrome in the school population. Ounsted considers that there is some evidence that epilepsy predisposes to hyperkinesis, but can exist without epilepsy. He related it to a history of status epilepticus or insult to the brain. There were only 3 of the 26 with neither. These 3 cases were not significantly retarded intellectually, while there was evidence of significant retardation in intellectual development in the remainder. The author's conclusion is that "cerebral damage acquired in the course of an initiating episode may be more important than the temporal lobe epilepsy in the causation of this syndrome." Blumer (1973) on the other hand classes it as an interictal disturbance.

It is of interest to compare these views with the findings in an epidemiological study investigating psychiatric disorders and physical disability in 11,865 school children in the Isle of Wight. Graham and Rutter/

Rutter (1968) found that psychiatric disorders were three times as common in children with physical disabilities as in normal children. In a group of "neuro-epileptic" children (including epilepsy and cerebral palsy) there were five times as many cases of psychiatric disorder as in normal children. However, Graham and Rutter do not interpret this as evidence of a specific behaviour syndrome associated with cerebral damage. On the contrary, they point out that the pattern of disturbed behaviour in the neuro-epileptic group is indistinguishable from that shown by neurotic and antisocial (non-neurological) children in the group. One method of assessment was the completion of a checklist of 26 behavioural items by the child's teacher. It was found that the endorsement of 9 or more items corresponded with the finding of disturbance on psychiatric examination. The pattern of items endorsed in the above groups included "squirmy, fidgety, irritable, restless, poor concentration."

The importance of attentional deficits in epilepsy in the school learning situation has been discussed previously (Stores, 1973). He emphasises the role of non-focal epilepsy whereas both Graham and Rutter (1968) and Ounsted et al. (1966) stress the importance of temporal lobe or psychomotor seizures in the disorders which they describe. The word "attention" is used in at least six different ways (Stores, 1973) and the type of impairment detected depends not only on aetiology but on the type of test used.

In discussing the hyperkinetic syndrome it is obvious, as it was in the discussion of temporal lobe and limbic involvement in aggressive behaviour and psychosis, that the distinction between cognitive function and other aspects of psychological function more traditionally related/

related to the emotional sphere, is an extremely artificial one. The recognition of:

(i) the role of subcortical structures in cognitive processes,

(ii) the re-analysis of the cognitive processes themselves, and

(iii) the study of the cognitive aspects of emotional functions,

seem to offer a more viable framework - although a very complex one.

Three areas of disturbed behaviour have been selected and discussed in relation to epileptogenic processes. It is not fully established how far these can be identified as (a) an integral part of seizure activity, as (b) subictal excitation, or as (c) resulting from the same cause as the epilepsy. However, the evidence offered does suggest a greater than chance coincidence between epilepsy and (i) aggressive behaviour, (ii) psychosis, and (iii) hyperkinesis.

There is also agreement that there is an augmented risk of psychiatric disturbance in patients with epilepsy in comparison with the general population (Tizard, 1962; Stevens, 1966; Graham and Rutter, 1968; Mignone et al., 1970). Such evidence, however, does not describe characteristic modes of behaving or a personality structure by which "the epileptic" can be identified. This is even more evident when it is realised that not only the three most frequently observed disturbances described above, but "almost every conceivable type of abnormal psychic and/or motor performance has been designated as a manifestation of psychomotor epilepsy" (S. Livingston, 1973). The list he presents includes arson, theft, sexual deviations, nymphomania, laughing and crying spells and enuresis.

Later Livingston argues in a similar vein that almost every type of behaviour and personality observation presented by epileptics has been/

been classified as a manifestation of an "epileptic personality." Livingston, like many others with wide experience of patients with epilepsy, is convinced that epileptics as a group do not present characteristic stereotyped personality changes or behaviour disturbances and therefore "dogmatically state(s) that a special syndrome such as an 'Epileptic Personality' does not exist." He bases this conclusion on his own experience of 20,000 patients over a 35 year period.

In contrast, in the 1962 edition of a textbook for students and nurses, written by a psychiatrist, the following appears: "(To recapitulate briefly) epileptics are shallow, religiose, hypocritical people.......Boastfulness, vanity, conceit, superciliousness and indiscipline are other characteristics." (Beccle, 1962).

To make such a statement is easy. To demonstrate the blatant falsehood of such a sweeping generalisation, by scientific research, is more difficult.

Tizard (1962), in a review of the evidence for "the epileptic personality", delineated five theories. Several of these have already been mentioned in different contexts in this review. The theories can be very briefly stated as follows:

(1) That all or most epileptics share a characteristic personality (as discussed above).

(2) That there is no characteristic epileptic personality, and the same range and combination of personality traits may be found among epileptics and non epileptics (Lennox, 1944).

(3) That there is no characteristic epileptic personality or personality disturbance, but a higher proportion of neurotic disturbance/

disturbance is found among epileptics than among non-epileptics (Bridge, 1949). Harper and Roth (1962) found a similarity between temporal lobe epilepsy and Roth's concept of the phobic-anxiety-depersonalisation syndrome.

(4) That there is no characteristic epileptic personality, but epileptics tend to have a personality resembling that of patients with organic lesions, which differs from that of normal persons (Bradley, 1951) and as discussed above (Ounsted, 1966), and in the specific case of psychotic disturbance by Slater and Beard (1963).

(5) That there is no characteristic personality common to all or most epileptics, but different types of personality are associated with different types of epilepsy. Tizard reports that as early as 1938, German authors were describing two distinct personality types, associated with idiopathic and symptomatic epilepsy. However, the delineation of temporal lobe epilepsy as a syndrome gave rise to a large number of studies, considering the behavioural and personality correlates of this syndrome. Tizard points to the difficulty in evaluating these studies, which vary in their criteria for classification and in assessment methods.

The review is very critical of the use in the majority of studies of a projective technique - the Rorschach Inkblot technique - to evaluate personality. Its inappropriateness for many of the patient groups studied, its known failure to discriminate groups reliably and other inadequacies are discussed.

Tizard's conclusion is that there is no support for the theory that all, or most, epileptics share a characteristic personality, but that the other theories cannot be confirmed or refuted because of the difficulties/

difficulties in classifying the nature of the epileptic disturbance and the "complex environmental and pathophysiological factors involved." The need to develop appropriate methods of assessing behavioural manifestations is stressed.

What progress has been made in the subsequent decade? Most of the studies appearing since 1962 have been concerned with resolving the issue of specific "psychomotor" psychological attributes.

In favour of a psychomotor/non-psychomotor distinction in psychological characteristics: Pond and Bidwell (1960); Court (1965); Ounsted (1966); Williams (1969); Weil (1959); Glaser (1968); Flor-Henry (1969); Small and Small (1968); Blumer (1973); Graham and Rutter (1968).

Against: Mignone et al. (1970); Small (1962); Stevens (1966); Livingston (1973); Currie et al. (1971); Rodin (1968).

The studies are diverse in terms of:

(i) Methodology (from Graham and Rutter's epidemiological study to matched groups (Small and Small).

(ii) Selection of cases (age range and whether from general neurological or psychiatric population).

(iii) Classification of the subjects in the study. The difficulties of classifying "epilepsy" and type of epilepsy have been discussed previously. In addition there are three interpretations of the relationship between "temporal lobe" and "psychomotor":

(a) The words are regarded as synonymous particularly by some American authors (Mignone et al., 1970; Horowitz et al., 1970).

(b) The words overlap in definition (Stevens, 1966; Glaser, 1968/

1968).

(c) The temporal lobe category includes the psychomotor category (Falconer, 1970; Currie, 1971).

(iv) Assessment techniques. While the question is generally considered to relate to <u>personality</u> in temporal lobe or psychomotor epilepsy, it is important to note that most studies describe or infer the presence of psychiatric or behavioural disturbance, rather than using the tools of personality assessment familiar to the psychologist (Stevens, 1966; Graham and Rutter, 1968; Bagley, 1971; Small and Small, <u>1968</u> as opposed to earlier publications by these authors).

Most present quite convincing evidence to support their standpoint. A number of these studies have already been considered. Some have been concerned with describing a selected group of temporal lobe or psychomotor patients and have indicated a high incidence of general or specific psychological disturbance (Court, 1965; Ounsted, 1966; Currie, 1971). From these it is difficult to generalise to wider samples.

The degree of confusion in this field is demonstrated by the fact that opposing statements appear in two different chapters in S. Livingston's book (1973) and also by the fact that other workers have changed their standpoint over time (Small et al. - see below). Some of the studies of different design, which appear to present conflicting evidence, must be considered in more detail.

Mignone et al. (1970) carried out a retrospective study of 113 cases of epilepsy, and a prospective study of 38 cases (excluding cases of mental retardation, neurological deficits or ongoing neurological or medical illness). The method of psychological assessment was/

was the Minnesota Multiphasic Personality Inventory (MMPI). The ten standard clinical scales yielded include depression, psychopathic deviant, schizophrenia and social introversion.

The conclusions drawn from this study were that the generally high incidence of mental disorder in epileptics was corroborated by both clinical descriptions and MMPI profiles. However, no evidence was obtained to support the rather common notion that mental disorders are predominant in epileptics of the psychomotor type (nor did they find in the small number of schizophrenics (10) any support for Flor-Henry's (1969) preponderance of dominant temporal lobe foci). Even with regard to specific issues of schizophrenia, aggressive impulsivity, sexual hypofunction and affective disorder, psychomotor epileptics were not distinguished from non-psychomotor epileptics.

It is important to compare this study with the work of Small and colleagues. Earlier work (Small et al., 1962, 1966) was in agreement with Mignone et al's finding viz. - no difference between matched groups of psychomotor and non-psychomotor cases, using standard questionnaire methods of assessment. However, in a more recent study (mainly concerned with comparing 89 patients with epilepsy and emotional problems with a control group of 89 psychiatric patients) it was found that <u>within</u> the epileptic group, there were significant differences in <u>psychiatric diagnosis</u> between patients with psychomotor epilepsy and those with other kinds of seizures. The authors explain this finding, discrepant from their own earlier work and other authors' findings, in terms of different age range and their inclusion of mentally retarded cases.

Small et al. consider their recent findings discrepant from

Stevens'/

Stevens' (1966) conclusions. It should be noted that Stevens reported that in a group of 100 patients with epilepsy there was no difference in the risk of mental illness between the psychomotor cases (54) and the grand mal cases (34). This is something quite different - Stevens is not here studying the type of psychiatric disturbance, merely the risk of any type of disturbance severe enough to lead to admission to a psychiatric hospital. This is her criterion of "mental illness."

Rodin (1968) concurs with this when he points out that a diagnosis of psychomotor seizures in a patient does not automatically imply a high degree of probability of the presence of behavioural problems. At this point he is using a logical argument and pointing to a fallacy which has led to much of the confusion in this field. Rodin accepts that a patient with epilepsy and with marked behavioural difficulties (especially if these are psychotic) is likely to have psychomotor seizures. However, he argues the converse stated above is not necessarily true. Even if we know that most patients with epilepsy and marked behavioural difficulties have psychomotor seizures, we cannot conclude that most psychomotor patients have behaviour difficulties.

If, however, we have information about the prevalence of psychomotor epilepsy then we can make some predictions. Graham and Rutter (1968) provide such information. In the normal school population in the Isle of Wight (11,865) they found eight cases with psychomotor fits (clinical classification). Six of these manifested disturbed patterns of behaviour. This is a significant proportion. This finding appears to contradict Stevens' (1966) conclusion, that psychomotor epilepsy does not carry an augmented risk of mental illness (as compared/

compared with other types of seizure). Apart from the obvious difference in the age range, it is important to note Stevens' criterion of "admission to a psychiatric hospital" for classification of mental illness. Rutter, on the other hand, uses a checklist completed by the teacher (including items such as "very restless; fights frequently; poor concentration; frequently sucks thumb or finger; fussy") with a cut-off score of 9 indicating psychiatric disturbance. It might be assumed that a higher frequency of disturbance would be detected by Rutter's approach.

The same approach was followed by Bagley (1971), who used checklists and interviews in a study of 118 children with epilepsy. He utilised factor analytic techniques on the data obtained. One of the main vectors which emerged relates to an aggression-anxiety dichotomy. He also found that aggressive behaviour was associated with "minor-motor" (mainly psychomotor) fits, low intelligence, environmental hazards (overcrowding, poverty, disturbing relatives, etc.) and negative parental attitudes.

How far the occurrence of seizures themselves produces a reactive behaviour disturbance has been questioned by many authors. From a study of 22 seizure patients with and 22 without behaviour disturbance, Rodin concludes that the behaviour difficulties in the epileptic patient are not primarily due to rejection by the environment as a result of seizures. Graham and Rutter (1968) found no evidence that the physical handicap of epilepsy per se produced the behaviour disturbance. However, considering the significantly higher incidence of disturbed behaviour in psychomotor patients, they suggest that "states of partial consciousness may well be more psychologically/

psychologically threatening to a child than a total loss of consciousness."

They also consider that the evidence from their study rules out the concept of a specific behaviour syndrome for children with cerebral damage. Rodin, on the other hand, while in agreement with the need to explain the behaviour difficulties in terms of more than a reactive disturbance, considers that cerebral damage and/or intellectual limitations are the causal factors, i.e. Graham and Rutter stress the seizure process while Rodin (like Ounsted, 1966) stresses the underlying brain damage.

Falconer and Taylor consider the concept of maturity a useful one. They endorse Rey et al's (1949) conclusion that some patients with epilepsy are "children in their EEGs and their personalities." In their series of patients with temporal lobe epilepsy Falconer and Taylor (1970) found immaturity and aggressiveness to be the most characteristic features of long-term interictal personality disorder, especially in cases of early onset epilepsy.

Bagley (1971) found that neither low intelligence nor the presence of minor-motor fits seem to be by themselves marked discriminants of aggressive behaviour. Only in combination with the two other variables (environment or parental attitudes) does the existence of these constraints lead to behaviour disorder. Bagley is concerned with an interactive approach to the problem. He points out that disciplines working in isolation and in enmity with one another, but on essentially the same problem, may produce diametrically opposed solutions to the same problem.

In the wider context of this review this adds further weight to the/

the need to avoid looking only at specific areas and looking for only one causal factor.

In the more immediate context of the psychomotor/non-psychomotor argument, Rodin considers that instead of denying that there is any statistical difference in regard to behaviour difficulties between psychomotor and other epilepsy patients, it would be more profitable to delineate that sub-group of psychomotor seizure patients in which behaviour problems are quite prominent.

This appears to offer the best prospect of progress in this field, since the evidence to date apparently seems to indicate that:

(i) In the patient with epilepsy and marked behaviour difficulties there is a high probability that he will have psychomotor seizures.

(ii) That as studied in children the occurrence of psychomotor seizures is associated with some disturbance of behaviour.

(iii) That it is difficult to demonstrate personality differences between a group of psychomotor and non-psychomotor patients, using personality questionnaires.

(iv) That demonstrating the existence of differences in psychiatric status between psychomotor and non-psychomotor cases depends on the assessment and method and the sample chosen.

Therefore the possibility exists that psychomotor patients do not constitute a uniform group. More careful study of (a) other factors in their environment, (b) the exact nature of their seizures, and (c) of the existence of cerebral damage is required.

The effect of removing the area of damaged tissue and/or of stopping the occurrence of seizures is the next aspect to be considered in/

in this review.

2(c) Effects of surgical treatment on personality and behaviour

Trepanning of the skull to cure epilepsy and mental disorders, by enabling the evil spirits to escape, was practised in primitive societies. Psychosurgery is usually regarded as a more modern therapeutic approach, its birth heralded by Egas Moniz who, with Lima, reported in 1936 that 20 intractable schizophrenics had been treated by frontal lobe surgery. In fact, as early as 1890 part of the left cerebral hemisphere had been removed in an attempt to relieve mental disorder (Burckhardt, 1890). Moniz's study had been preceded by a report by Fulton and Jacobsen (1935) that bilateral removal of the frontal lobes in chimpanzees led to a state of indifference in situations which had produced frustration or anger pre-operatively.

The excessive enthusiasm following these initial reports, which resulted in patients being indiscriminately subjected to surgery, is widely recognised. Tooth and Newton (1961) reported on 10,000 cases operated on between 1942 and 1954. That there are still patients in whom the side effects were adverse in the chronic wards of psychiatric hospitals in this country makes many psychiatrists very hostile to the idea that neurosurgery has anything to offer the mentally disturbed patient. Nevertheless, there is considerable evidence that with careful selection of cases, and modified techniques, the therapeutic effects are dramatic. In this country, attention has tended to be focused recently on phobic and obsessional symptoms rather than schizophrenic ones, and careful studies indicate that surgical intervention is worthwhile (Kelly and Mitchell-Heggs, 1973).

Parallel with Fulton and Jacobsen's experimental work on frontal lobe/

lobe ablations in chimpanzees, studies were being carried out on the temporal lobes of monkeys. Klüver and Bucy published a preliminary report on the functions of the temporal lobe (1939). Following bilateral removal of the temporal lobes, monkeys exhibited (1) strong oral tendencies; (2) marked changes in emotional behaviour or the absence of emotional responses in the sense that motor and vocal responses generally associated with anger and fear were not exhibited; (3) an increase in sexual activity; (4) a strong tendency to attend and react to every visual stimulus. There were also disturbances in previously learned responses.

In 1955 Terzian and Dalle Ore published a paper entitled "Syndrome of Klüver and Bucy reproduced in man by bilateral removal of temporal lobes." Profound memory disorder and compulsive masturbation were among the more disturbing effects reported. Unilateral temporal lobectomy was known to have far less severe effects. Nevertheless Hill et al. (1957) in a follow-up (2-5 years) study of patients with temporal lobe epilepsy treated surgically by Murray Falconer, referred some of their findings to the Klüver Bucy syndrome. They reported a decrease in overt aggression; a turning-in of aggression (this led to depression, noted up to 18 months postoperatively); an increase in sexual drive and warmth in social relationships (this was associated with the decrease in aggression).

It must not be assumed that it was Klüver and Bucy's work which precipitated the surgical treatment of epilepsy. In 1886 Sir Victor Horsley excised a focus from the right hemisphere of a ten year old boy. The boy's severe generalised fits had local onset in "the left angle of the mouth." At operation the facial area in the right hemisphere/

hemisphere was exposed, the focus being determined "by excitation."

In 1928 Penfield began to operate upon the temporal lobe for relief of medically refractory focal epilepsy. The unique contribution made by Wilder Penfield has been indicated earlier in this review. His studies of the psychological effects of stimulation of various temporal areas were discussed, as were the effects of unilateral temporal lobectomy on cognitive function as studied by himself and his colleagues. His success in alleviating epilepsy cannot go unmentioned. Rasmussen (1973) reported on 1,112 patients who had undergone surgery in the Montreal Neurological Institute between 1928 and 1970. This is the longest series of temporal lobectomy cases in any one unit. Four hundred and thirty patients became and remained seizure free postoperatively. Altogether 67% obtained marked seizure relief.

The experience of 45 years in over 1,000 cases is invaluable in the clinical selection of cases likely to benefit from surgery. The possibility of using a statistical model in prognosis was studied by Bengzon et al. (1968). From patients in the Montreal series two groups (about 50 in each) were selected, one in which surgery had been completely successful, and the other in which no worthwhile relief of seizures had been obtained. The two groups were then compared on a number of variables. Among the factors more frequently associated with the failure group, and therefore regarded as a contraindication, was psychiatric disturbance. In fact, only 23% of this series showed any psychiatric disturbance pre-operatively. This is a much lower incidence of psychiatric disorder than that in many other series. This might imply that psychiatric disorder had been considered/

considered an indicator of poor prognosis long before the study by Bengzon et al. in 1968.

Much less attention has been paid in the vast series of Montreal patients to postoperative changes in emotional state, attitudes and adjustment than to seizure relief and aspects of cognitive function. Commenting on the use of seizure relief as the criterion of success in the Montreal series, Falconer and Taylor (1970) point to the need to consider other aspects of postoperative effectiveness. Postoperative emotional changes and psychiatric status had been studied previously. In a more recent analysis, the effect of temporal lobectomy on the life of the patient was considered. The outcome of surgery was evaluated in terms of social adjustment. Patients were rated on 64 variables, many of which were social in character (the reliability of the scales used was carefully tested). Analysis of the variables showed that the patients who improved most were most relieved of epilepsy. Those who remained poorly adjusted were least relieved of epilepsy, had high psychosis and psychopathy rates, and an excess of lesions of no specific pathology; among them there was an excess of patients below the median I.Q.

Seizure relief was linked to the pathological changes in the resected specimen (with greatest relief in cases of mesial temporal sclerosis) and hence it was found to be the excision of the epileptogenic focus which plays the cardinal role in the outcome.

However, Horowitz et al. (1970) stress that psychosocial rehabilitation does not occur automatically with seizure relief. Their study of patients with psychomotor seizures treated by temporal lobectomy and stereotactic lesions has been mentioned previously. They/

They found turbulent upheaval not uncommon in patients relieved of seizures, and not necessarily a poor prognostic sign. They point out that a very depressed, dependent patient, free of seizures one year after lobectomy, may be functioning well and reasonably contented after two years. They describe seven psychosocial rating scales which cover areas such as personal satisfaction, adaptation to illness, paranoia. As mentioned in considering the findings of this study in the area of cognitive functioning, it is unfortunate that their own results are much less clearly stated than their theoretical standpoint. Despite this, their paper is considered a very important one in attempting to bridge the gap between neurophysiological and psychodynamic formulations in an area often regarded as the exclusive right of the neurophysiologically orientated psychologist. They consider psychotherapy essential postoperatively and suggest it should focus on the patient's struggle to reformulate his identity, to re-evaluate his capacity and residual impairments, and to establish a new pattern of transactions with his family, friends and workmates. Thus Horowitz is much less concerned with brain-behaviour correlates and more concerned with the significance of the experience of epilepsy and of the effects of surgery on the individual patient. This point of view merits consideration even by those out of sympathy with his particular dynamic position.

In Falconer and Taylor's series of 100 patients, only 13 were regarded as psychiatrically normal pre-operatively, while postoperatively 32 were normal. Fifty-one patients showed a good level of social adjustment postoperatively, while only 34 had done so preoperatively. The greatest improvement was noted in working ability and/

and interpersonal relationships rather than in the use of leisure or sexual adjustment.

Of 16 patients who were psychotic immediately pre-operatively, those with confusional symptoms responded to surgery. However, in the 12 who showed schizophrenic or paranoid symptoms, the psychosis persisted even though the epilepsy was relieved. None of these cases had mesial temporal sclerosis, whereas this was the pathology in 47% of the series.

Falconer and his colleagues take up a position intermediate between the Montreal standpoint that psychiatric disturbance is a contra-indication to surgery, and that of Green and Scheetz (1964), who consider neither psychiatric disturbance nor mental defect should be regarded as a contra-indication and report worthwhile rehabilitation in cases of psychosis and mental defect. Falconer's experience is of a majority of cases whose psychiatric status was abnormal. Many of these cases improved postoperatively, but mental defect and schizophrenia do seem to carry a poor prognosis.

Thus these neurosurgeons have differed in their criteria for selection of patients. All, however, have insisted on either definite clinical evidence of psychomotor seizures or EEG evidence of a unilateral temporal lobe focus. More typically, they have insisted on both clinical and EEG evidence. Rodin points out that only 1.5% - 3.6% of patients with epilepsy investigated in different units fulfil the criteria for selection for unilateral temporal lobectomy. He considers the reason to be that the great majority of patients with psychomotor seizures have bilateral EEG abnormalities. Bilateral temporal lobectomy was excluded by the reports discussed above

(Scoville/

(Scoville and Milner, 1957; Terzian and Dalle Ore, 1955).

The possibility that such disastrous results could be avoided if only small selected areas of tissue were destroyed bilaterally was considered. Such selective destruction was possible with the use of stereotactic procedures (discussed in the previous section). Avoiding adverse side effects was only one of a number of reasons for the development of additional surgical procedures.

In approximately 20% of cases of temporal lobectomy no pathology is demonstrated (Falconer, 1970). In some such cases seizure relief has followed surgery (Bates, 1962). This gives rise to the question of the therapeutic effect of interrupting neuronal circuits and altering the function of the remaining tissue, as opposed to the effect of excision of an area of pathological tissue.

If a functional approach is to be adopted, the targets for such procedures would be seen as those associated with lowered thresholds for abnormal epileptic activity. This might seem especially valid where clinical seizures exist but no cortical focus (EEG) is demonstrated. Certain mesial temporal and limbic structures, especially the amygdala, have been shown to be highly excitable electrically (see above; Gloor, 1960).

These are also the structures implicated in the regulation of emotional behaviour. Where neurosurgical intervention is aimed at the modification of disturbed emotional behaviour, in the absence of evidence of epilepsy, the procedure is a psychosurgical one. This distinguishes it from the same procedure in the same brain area which is carried out for the relief of epilepsy. Where the rationale is framed in terms of the disturbed behaviour as an "epileptic equivalent"/

equivalent" the issue becomes very blurred.

It is often assumed that the introduction of amygdalotomy as a therapeutic approach to behaviour disorders was precipitated by the extensive data on the role of this nucleus in the regulation of aggressive behaviour in a number of animal species. Eleftheriou (1972) edited an entire volume entitled "The Neurobiology of the Amygdala." An earlier paper by Gloor was published in 1960, detailing the evidence on the functions of the amygdala. It is therefore of interest to note that Narabayashi, reporting in 1963 on 60 patients who had undergone amygdalotomy, refers only to human studies in giving his rationale for selecting the amygdala as target for destruction (Narabayashi et al., 1963).

Initially cases were selected on the basis of psychomotor seizures, focal spike discharges on EEG, and marked behaviour disturbance (such as hyperactivity and assaultive behaviour). Later the criterion of overt seizures was dropped and finally several cases of behaviour disorder without epileptic manifestations (either clinical or EEG) but associated with mental subnormality were included. Narabayashi reported on 60 cases aged 5-35, in 46 of whom epilepsy was diagnosed and in a further six there was evidence of EEG abnormality.

As with the majority of studies subsequently published, the results are reported in terms of graded improvement. No mention is made of possible difficulties in evaluating behaviour accurately. The only comment on method of assessment refers to "careful and repeated observations" failing to detect any evidence of Klüver-Bucy syndrome postoperatively. There is no mention of who the raters are or/

or the periods of observation on which ratings were based. Grade A signified "almost complete disappearance of emotional excitement and that the child has become educable and socially adaptable." Grade B was used for cases which showed relative improvement, C only slight improvement and D no improvement. Eighty-five per cent of cases showed at least moderate improvement (Grades A and B) at least in the short term, although longer term results were not quite so good (Narabayashi, 1972). They found relatively little change in seizure patterns postoperatively.

Violent, aggressive and restless behaviour in 43 cases requiring constant watching by family or police was treated by placement of stereotactic lesions in posterior hypothalamus by Sano (1972). Postoperatively 13 cases showed no recurrence of violent or restless behaviour; these were classed as excellent (the other two categories being "good" and "unchanged"). In 95% of cases there were "marked calming effects." In contrast with Narabayashi, Sano reported that 9 of 22 cases of intractable seizures were controllable postoperatively.

Balasubramaniam and Kanaka (1973) compared the efficacy of amygdalotomy and hypothalamotomy in a sample of 205 cases. This time a 6 point scale is used:

A - "No need of any drug";

C - "Manageable when given drugs, though not leading a useful life";

F - "Died."

They report that 76% of the sample benefit from surgery (Grades A-C). They conclude that both amygdalotomy and hypothalamotomy alleviate/

alleviate symptoms of aggressive assaultive behaviour and fits, but neither is very effective in alleviating restlessness. They seem to find unilateral amygdalotomy plus unilateral hypothalamotomy is equivalent to bilateral hypothalamotomy. In this series only 35% were epileptic, but in 95% there was evidence of some organic damage (over one third of the cases were postencephalitic).

These three studies have been selected as representative of an increasing number in this field, all giving cause for concern in their simplistic approach to behaviour and its evaluation. This contrasts with the sophistication of their stereotactic techniques, which can lead to uncritical replication by neurosurgical colleagues.

However, in fairness to Narabayashi, whose 1963 study has been criticised, a more recent publication (Narabayashi, 1973) must be mentioned. In this he describes a method of observation of hyperkinetic children in a specially equipped room. The subsequent statistical analysis of 20 minute samples of behaviour showed marked improvement in span of concentration postoperatively. Such patients are notoriously difficult to assess and this type of approach has much to commend it.

Two American neurosurgeons operating in the field of behaviour disturbance, who have also recognised the problem of assessment of behavioural change, are Heimburger and Andy. Unfortunately, in the attempt to arrive at an answer to the question, "Is the patient better?" they have undermined the value of their assessment schemes insofar as they insist on combining results obtained on a number of different variables. They do this in order to provide a score or index of change in level of disturbance. Thus, in Heimburger's study a/

a patient's fit frequency may have declined and he may have become less aggressive. He may also have been released from an institution (possibly as a result of the previous two factors). His postoperative score represents the sum of the changes between pre- and post-operative ratings in all these areas. This may lead to distortion. Thus Heimburger's conclusion that behaviour abnormality was markedly improved in 9 cases could be open to question. He is reporting the results of amygdalotomy in 20 cases of epilepsy and aggression. However, in addition to the overall score he reports that 2 of 12 patients committed to mental institutions were released; that behavioural abnormalities were eliminated in 7 cases; that seizures were eliminated in 4 and reduced in 12 cases. Thus there is considerable evidence that a number of patients were helped by the procedure. It must also be pointed out that in contrast to the above studies, Heimburger does provide descriptions of behavioural patterns used in classing "hostile", "aggressive" and destructive behaviour (Heimburger et al., 1966).

An overall measure of improvement was also used by Jurko and Andy. They calculated a pre- and post-operative "Problem Severity Index" for each of 30 cases (aged 6-49) treated by lesions in the centrum medianum thalamic zone to alleviate the hyperresponsive syndrome. The patients were found to show three predominant symptom patterns: "aggression, hyperkinesia and patho-affect." Aggression is subdivided into self aggression (mutilation, etc.) and social aggression, which consists of motor, vocal and social deviance aspects. "Patho-affect" is subdivided into personality traits and emotional states. A number of behavioural items in each symptom pattern/

pattern were listed and were weighted according to the acceptability to society and detrimental effect on the individual. Items included: tantrums, argumentative, stealing, restless and withdrawn. Each patient's scores for the three areas were transformed in such a way as to provide ratings on a four point scale. The same was done for other variables - I.Q., other psychological test results, and neurological deficits. These were then added to give a problem severity index for each individual. The authors point out that two patients with a very different pattern could have the same index (Andy and Jurko, 1972).

Postoperatively 6 of the 30 patients were 75%-100% improved and 14 were classed as fair (25%-75% improvement). The greatest improvement was reported in the predominantly aggressive group and least in the predominantly patho-affective group. It is possible, however, that these results are partly a function of the difference between the type of items in the "patho-affect" and "aggressive" categories.

It is desirable to have an overall measure of change. However, if the method of obtaining this is based on arbitrary allocation of numerical values to a range of variables such as fit frequency and personality traits, there are serious risks of distortion. It might be argued that this is less dangerous where a comparison of the efficacy of some surgical procedure in treating different symptom patterns is being made than in a study claiming to provide an absolute measure.

Two further studies of amygdalotomy must be considered in which any attempt at quantitative assessment has been eschewed in favour of the case history method, of tabulation of individual results.

Sweet et al. (1969) have suggested that amygdalotomy might be beneficial/

beneficial in patients without signs or symptoms of epilepsy but with episodic aggression. However, in their report of cases treated so far, all 10 had some evidence of seizure disorders. Symptoms tended to recur 6-9 months after unilateral amygdalotomy, but lasting relief (follow-up 2-7 years) was obtained in 4 of 6 patients with bilateral lesions.

Vaernet and Madsen (1970) report on 12 of a series of 51 patients with mesiobasal EEG foci treated by stereotactic amygdalotomy. They all were female (age 23-69) with violent aggressive behaviour. Five were cases of personality disorder and six were psychotic. In 11 cases amygdalotomy resulted in disappearance of or reduction of frequency of aggressive behaviour.

What can be said to summarise this conglomeration of reports, no two of which seem to be directly comparable? What are the effects on personality and behaviour of surgery designed to modify epilepsy, behaviour disturbance or both? Only Falconer and Taylor's study can be regarded as of a standard equivalent to that attained in the study of cognitive function in surgical cases, and the standard of some of the studies of personality and behaviour in epilepsy (not surgical cases).

Perhaps the standard is low because this is an exceptionally difficult area? Or perhaps it is because the neurosurgeon is unaware of the biased, subjective nature of his evaluation?

Whatever the reasons, the majority of studies (such as those reporting 95% success) are regarded with scepticism. The overall impression is that the results show change in whatever area of behaviour change was expected postoperatively (aggression, mood, attitudes/

attitudes, etc.) Nevertheless, with so many reports centring on the role of the amygdala in specifically reducing level of aggression, this is a procedure well worth closer scrutiny.

2(d) Related neurosurgical procedures

Mention has already been made in the preceding section of surgical approaches to the treatment of mental disturbance. It is not appropriate to review the literature in this field. However, as was the case with cognitive function, specific psychological findings from neurosurgical procedures for conditions other than epilepsy, will be mentioned where these are of relevance to the present study.

Jurko and Andy (1973) have reported changes in Rorschach responses in 25 patients undergoing thalamotomy for the relief of Parkinson's disease. In the early postoperative stage (5th day) there was an increased response "to the more evident and sensorially vivid aspects of the environment" (as colour and movement). At this stage there was also an increase in extraversive tendencies. These changes had reversed by two months postoperatively.

Orchinik (1962) also found differences between Rorschach responses on short-term (1 week - 2 months) and long-term (3 months - 1 year) follow-up of 17 neurotic and psychotic cases treated by thalamotomy. The only short-term change was a decline in the number of W (whole) responses; this persisted in the long term when other changes were also detected. There was a decline in reaction time and in the number of cards rejected. This was interpreted as indicative of "greater emotional tolerance in meeting with certain environmental stresses and demands." The significant increase in responses using Form and Colour and Animal Detail was interpreted as/

as showing "greater social adaptiveness." Clinical observations on these patients (Spiegel and Wycis, 1962) included the finding that in successful cases tension was reduced and patients were relieved of their fears, anxieties and depression. In some patients initiative was reduced, but in others increased "perhaps due to reduction of the restricting influence of their fears." In 4 cases libido was transiently increased. "Most of the undesirable sequelae of prefrontal lobotomy did not appear."

The effect of psychosurgical procedures on behaviour was discussed by Willett (1962). He reviewed 32 studies of frontal lobe surgery. He found that personality questionnaires had yielded surprisingly little information but warned that the findings from projective techniques must be treated with the usual reservations. In considering further all the available evidence from the clinical reports, objective tests and animal studies, Willett was unable to draw any conclusions about the reduction in disease tendencies (psychoticism and neuroticism) postoperatively. However, he found the evidence strongly suggestive of a decrease in introversion following surgery, but comments that "the efforts of clinicians and psychologists investigating the effects of psychosurgery have often been repetitious and wasteful."

More recently Ursin (1972) has pointed to methodological inadequacies. He argues that none of the human studies presented at the Third International Congress in Psychosurgery (Cambridge, 1972) would have been accepted by any behaviour journal if the subjects had been rats or cats. Ursin seems to be unaware that standardised assessment methods can be used to provide valid and reliable measures of/

of change in a well designed study - such as those by Kelly et al. (1973) using standardised questionnaires to measure mood, and Falconer (1973) using a reliable rating scale to measure social adjustment. These are not open to the type of criticism which Ursin makes. However, it is unfortunately true that such methods are not used in the majority of studies in this field.

One intention of the current review has been to indicate the extent of deficiencies in design and method. Paradoxically this is even more evident in psychosurgical studies than in studies of the effect on behaviour of the surgical treatment of epilepsy.

Ursin is also critical of the concepts used in the evaluation of the behaviour of psychosurgical patients. "Fear and aggression are terms too gross to be useful in neuropsychological research." He considers this has been less obvious than it should have been because large unspecific lesions are being made in which there is no need for refinement in evaluation. Ursin is comparing the lesions of both open and stereotactic psychosurgery with the precision of techniques used in animal studies.

This is an interesting criticism, since one of the main arguments advanced in favour of the stereotactic approach is that it enables precise localisation of specific target areas for destruction. In many studies mentioned above, this target has been the amygdala. However, within the human amygdala there are 23 subnuclei (Vowles, 1970). Antagonistic patterns of response - flight and defence - have been elicited from adjacent amygdaloid zones in the cat and the monkey. These studies show that "small lesions and specificity in the analysis of functions enable localisation and organisation./

organisation. Large unspecific brain lesions tend to reveal equipotentiality and non-localisation." (Ursin, 1972).

Are Balasubramaniam and Kanaka (1973) perhaps expressing the same idea when they suggest that the choice of targets depends "on the quantity of behavioural brain that needs to be eliminated."?

2(e) Miscellaneous

At a rather different level of explanation, the non-localisation issue has been considered alternatively in biochemical terms by Shute (1973). He hypothesises that the similar results achieved from differently sited lesions may result from diminution of cholinergic activity; it is notable that the main targets in psychiatric surgery are the site of cell bodies (e.g. globus pallidus and substantia innominata), axons (cingulate white matter) and terminals (medial thalamus and amygdala) of neurones believed to be cholinergic. He suggests that the beneficial effects of amygdalotomy on aggressive behaviour may be due to suppression of the input to cholinergic centres in the posterior hypothalamus.

At this level of explanation surgery and pharmacology can be seen as alternative therapeutic approaches to redressing the cholinergic-monoaminergic balance. Similar biochemical mechanisms have been implicated in seizure activity. Acetylcholine and electrolyte metabolism are directly related to the mechanisms concerned with functional activity of neurones and the excitable membranes. Instability, decreased threshold for excitation and repetitive activity can be promoted at the excitable membrane. Factors involved in this are excess excitatory transmitter and flow of ions (influx of sodium, efflux of potassium). These give rise to seizure activity/

activity, althouth it is not yet known why imbalance occurs (Tower, 1965).

Thus, in addition to the previously established link between epilepsy and emotional disturbance in their mutual association with limbic structures, there is some evidence of a biochemical link, through catecholamines. This link has been used in pharmacological as well as in surgical approaches. The anticonvulsant drug sulthiame (Ospolot) has been found effective in decreasing aggressive and hyperactive behaviour in both epileptic and non-epileptic children (Al-Kaisi and McGuire, 1974). Diphenyl hydantoin has also been reported as successful in controlling episodic aggression in a number of cases, some with EEG abnormalities, but all interpreted as having "a central nervous system containing neurones which undergo occasional rapid transient local discharge" (Turner, 1970). Barbiturates, on the other hand, often tend to increase or produce restless and unstable behaviour (Blumer, 1973). The paradoxical effect of stimulants (amphetamines) in the control of hyperkinesis has been explained by Livingston in terms of the inhibitory function of certain neurones on other excitatory neurones. He finds plausible the concept of modifying hyperkinesis by stimulating inhibitory cells. In fact amphetamines are his drug of first choice in treatment of hyperkinesis.

The differential effect of drugs on behavioural parameters in epileptic patients has been the subject of a number of studies by Hutt and Hutt (1964, 1970). These authors have developed methods of observing, recording and subsequently analysing behaviour derived from ethology. This enables much more precise information to be collected/

collected in a group of patients resistant to most conventional forms of assessment. For example, they have demonstrated that in a hyperkinetic epileptic child sulthiame (Ospolot) increased attention span and reduced oral and destructive tendencies to a greater extent than thioridazine (Hutt et al., 1966).

The reviewer cannot be considered competent to evaluate the evidence of the biochemical basis of epilepsy but it does appear that the relationship between epilepsy, anticonvulsants and behaviour is also a complex one which cannot be adequately dealt with in this review.

3. CONCLUSION TO LITERATURE REVIEW

It must be remembered that this study arose because the neurosurgeon wanted to know what changes occurred in a patient's behaviour postoperatively. He asks the question for two reasons:

(1) To ascertain whether his operation has been successful in treating the patient with epilepsy.

(2) To monitor adverse side effects of surgery.

Therefore, the review of the literature was carried out not so much to find a question to ask, but more to find out how other people had set about answering similar questions. In addition it was hoped to find the most appropriate way to frame the question from the standpoint of the psychologist.

The review was designed to place the problem in the general context of (i) the association between epilepsy and the entire spectrum of psychological function, and (ii) the evaluation of behaviour, with a surgical procedure as the independent variable.

An attempt is now made to summarise the foregoing review.

1. At the outset, the problem was to see how abnormality in the structure or function of various areas of the brain affected psychological function. These effects could be the result of (a) ongoing epileptic activity, (b) damage as a result of epileptic activity, or (c) therapeutic removal of epileptogenic areas.

2. In the absence of an adequate explanation for the occurrence of the epileptic disturbance or of the process itself, it is perhaps not surprising that there is great confusion about correlates of the epileptic process. There has been at times an almost obsessional desire throughout this review to establish how far certain types of experience/

experience and behaviour can be identified as an integral part of seizure activity. In the present state of knowledge this is not possible.

3. The review has not been very productive in terms of providing models on which to base further studies of effects of surgical treatment. This is particularly true of the area of personality and behaviour. It is less true of cognitive function.

4. Analysis of the variables in cognitive function in epilepsy has indicated the great complexity and stressed the need to consider the interrelationships between different aspects of cognitive functions themselves, and those between cortical and subcortical brain structures. There is much data (some conflicting) on the effects of certain lesions and ablations, but one structure whose role in learning and attention has been much more carefully studied in animals than in man is the amygdala. The role of the thalamus and its pathways have been indicated in some disturbances of cognitive function associated with epilepsy. In addition, the effect of stereotactic lesions on cognitive function has been studied. However, where such surgical procedures have been carried out for the relief of epilepsy, effects on cognitive function have not been studied in detail.

5. Of at least equal complexity is the relationship between personality, emotional state and epilepsy. There is evidence that organic factors, the epileptic seizure itself and the environment in which this takes place, all contribute to the behavioural disturbances which are over-represented in the population of patients with epilepsy.

6. In contrast, there are a number of studies reporting a straightforward/

straightforward surgical cure of severe behavioural disturbance in epilepsy. Many of these do not even mention that there are difficulties in assessing behavioural change. This is indicative of the distance between some neurosurgeons and the psychologist in their concepts of behaviour.

7. It is easy to mock the naïvete of the non-psychologist. However, attempts to criticise these and other studies in a constructive rather than a destructive way, have indicated that many of the psychologist's concepts are much less amenable to objective evaluation than was recognised at the beginning of the study.

8. The review has touched on many theories of brain behaviour relationships. Some have emphasised the role of cognitive processes, others emphasise pathways and systems within the brain at a neuroanatomical level (Nauta, 1973; Livingston, 1973) and in biochemical terms (Shute, 1973).

In the human field some workers have not attempted to test the hypotheses generated by their theories; others have presented evidence which does not seem to verify their theoretical standpoint, while others provide no theoretical framework at all but on an empirical basis make certain lesions in an attempt to produce specific behavioural changes.

9. Scientific inquiry should follow an orderly sequence of observation, description, theory, which generates testable hypotheses, which verifies or refutes the theory, which is modified accordingly. Human problems do not obey such an orderly sequence, nor do attempts to solve the problems. The researcher may hope to compromise between the two. More often than not he has to make a choice.

In/

In the present study the choice seemed to be required between:

(a) testing hypotheses generated by theories not yet adequately developed to explain disturbed human behaviour, and

(b) attempting to answer the neurosurgeon's empirical questions by using existing methods of evaluating behaviour.

The questions below indicate that the latter was chosen.

WHAT IS THE PRESENT STUDY INVESTIGATING?

WHAT IS THE PRESENT STUDY INVESTIGATING?

"Are particular neurosurgical procedures associated with particular patterns of change in cognitive function, personality and behaviour?"

It is now more appropriate to ask three more detailed questions:

(1) Do patients undergoing unilateral temporal lobectomy, stereotactic amygdalotomy and stereotactic "central"* lesions demonstrate particular patterns of change in general intellectual level and in specific aspects of memory, learning and reaction time?

(2) Can postoperative changes be demonstrated by the use of standard personality questionnaires? If so, are these changes related to the site of surgery?

(3) Do patients undergoing amygdalotomy show changes in their pattern of aggressive or other disturbed behaviour?

In addition to the main study of the effects of surgical treatment, the opportunity should be taken of describing a larger sample of patients undergoing neurological investigation of epilepsy.

Reviewing the literature has suggested the following hypotheses:

(1) That a sample of patients undergoing neurological investigation are likely to differ from other selected samples of patients with epilepsy and deviate from normal in aspects of cognitive function, personality and behaviour.

(2) That within a sample of patients undergoing neurological investigation/

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* See Methods Section for explanation

investigation those with indications of psychomotor epilepsy (based on either clinical or EEG evidence) will differ in selected aspects of cognitive function, personality and behaviour from these patients with epilepsy in whom there is no evidence of focal disturbance. This will be more specifically tested as follows: that cases of psychomotor epilepsy will show less deficit in intellectual function but will be more disturbed in behaviour and personality than cases of non-psychomotor epilepsy.

(3) That within a sample of patients with epilepsy undergoing neurological investigation, those selected for surgery will show more indication of deficit in intellectual function and will be more disturbed in behaviour and personality than those not selected.

METHODS

METHODS

"Is it not in the nature of things that action should come less close to truth than thought?"

Plato

1. Placing the present study in context

In 1967 a research project on the surgical treatment of epilepsy began in the Department of Surgical Neurology, Royal Infirmary and Western General Hospital, Edinburgh, under the direction of Professor John Gillingham*. Since it was likely that the number of patients would form only a very small proportion of the case load of each of the four neurosurgeons, it seemed most appropriate to conduct the study within the existing clinical framework. In addition to the neurosurgeons, other members of the departmental staff - neurologist, neurophysiologist and a psychologist - were invited to join the project, as were a biochemist and two neuropathologists. It was anticipated that other consultants within the Department of Surgical Neurology - radiologists and anaesthetists - would be involved in both investigative and surgical procedures. Nursing staff would be involved with inpatient care. The role of paramedical staff, speech therapists, occupational therapists and physiotherapists and medical social worker, would remain as in the normal clinical procedure, with referrals for assessment and rehabilitation as considered appropriate by/

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* This project was made possible by a very generous grant from the MacRobert Trust.

by neurologist or neurosurgeon.

Each of the four neurosurgeons expressed interest in a specific area of the surgical treatment of epilepsy. Their research plans were included in the 1968 Annual Report to the MacRobert Trustees, as were the plans of the other consultants:-

"The Chairman, Professor Gillingham, elected to study pathways of epileptic discharge.

Mr. Harris took up the problem of depth recordings in temporal lobe epilepsy.

Mr. Shaw planned a study of the aetiology and progression of epilepsy in children.

8 Mr. Hitchcock undertook the study of behavioural and autonomic disorders associated with epilepsy, confining his interests to the limbic pathways.

Dr. W.S. Watson proposed to examine the indications for surgical treatment and to prepare a standard system of examination, charting and data retrieval.

Dr. Townsend was prepared to co-operate with the surgeons requiring electroencephalographic studies, and was interested in quantitating electroencephalographic records by computer to facilitate long-term studies. A 903B Elliott Computer was set up in the Department in October 1967 by the Medical Research Council and on-line facilities with the University Computer became available in February 1968.

Dr. Jordan, under the supervision of Professor Perry and as a preliminary study, undertook an investigation into cerebrospinal fluid, amino acids and other amides to determine whether these substances/

substances were changed in epilepsy. Later histo-chemical methods on small biopsies would be considered.

Dr. Maloney and Gordon were prepared to examine the pathological material and pursue the possibility of electron microscopic studies if facilities could be arranged.

Dr. Naughton would carry out routine serial psychometric studies on those patients accepted for the study.

It was agreed that each surgeon should attempt to study one patient a month who would be accepted for the project."

In 1969 it was decided to appoint a Research Associate to expand the area of psychological assessment, under the supervision of the psychologist already engaged in the project. The current presentation represents the work carried out, with this remit, by the author in the ensuing four and a half years.

2. The current study

In designing the prospective study it was desirable to have some estimate of the probable number of cases. A retrospective study of available cases records of patients treated surgically and on whom psychological assessment had been carried out, with a more detailed analysis of cases treated since the outset of the MacRobert Research Project, indicated that four main groups could be expected:

(1) Cases referred for investigation of symptomatic epilepsy, which may be amenable to a variety of neurosurgical procedures (e.g. insertion of a valve to control pressure in hydrocephalus, excision of neoplastic tissue, evacuation of a cyst).

(2) Cases selected for temporal lobe excision (referred to in the study as "temporal lobectomy cases"). These cases suffer from seizures/

seizures, have EEG evidence of a focal source of epileptic discharge in the temporal lobe, may or may not be disturbed in behaviour, or mentally retarded. Fig. 4 again shows some of the structures involved, depending on the location and extent of excision. In a typical case only the anterior 5 cm. are excised.

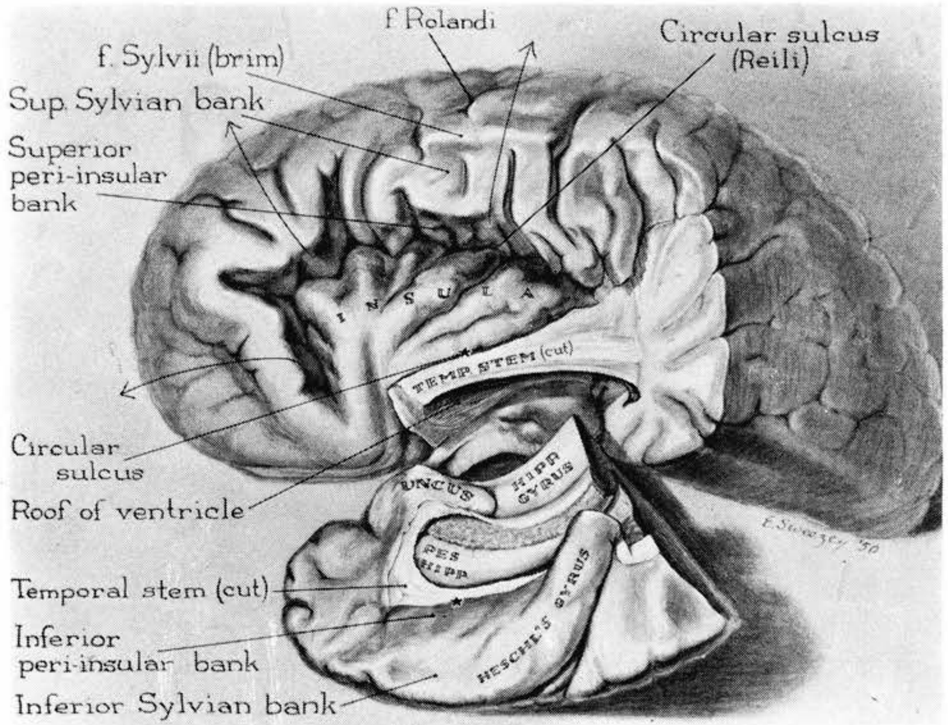
(3) Cases selected for placement of stereotactic lesions in central areas of the brain, interrupting possible pathways of epileptic discharge. Target sites include Field of Forel, thalmus, internal capsule and pallidum. In the present study these cases are referred to as the "central" group. These cases suffer from epileptic seizures, but EEG and other investigative procedures fail to indicate any focal source of abnormality. They may or may not be disturbed in behaviour or mentally retarded. Figs. 5 - 7(i) show the technique and sites of lesion. Some idea of the location of these in relation to temporal structures is given in Fig. 7(ii).

(4) Cases selected for stereotactic amygdalotomy. These cases may or may not have epileptic seizures; they do not show a unilateral focal source of abnormality; they are disturbed in behaviour and may or may not be mentally retarded. Figs. 8 and 9 show the technique and site of lesion.

Fig. 10 provides a general guide to the location of these three main procedures as well as indicating a number of others.

The cases in group (1) do not come within the chosen area of study of any of the neurosurgeons and there has been discussion about whether they should be included, as they are a rather diverse group in whom the rationale for surgery is not primarily alleviation of epileptic seizures, but treatment of the underlying pathological condition.

Including all these four groups the retrospective study indicated



Human brain with left temporal lobe cut and turned down. It shows the continuity of the superior surface of the lobe with the mesial surface, in the uncus, and with the cortex of the insula at the bottom of the circular sulcus

Fig. 4.

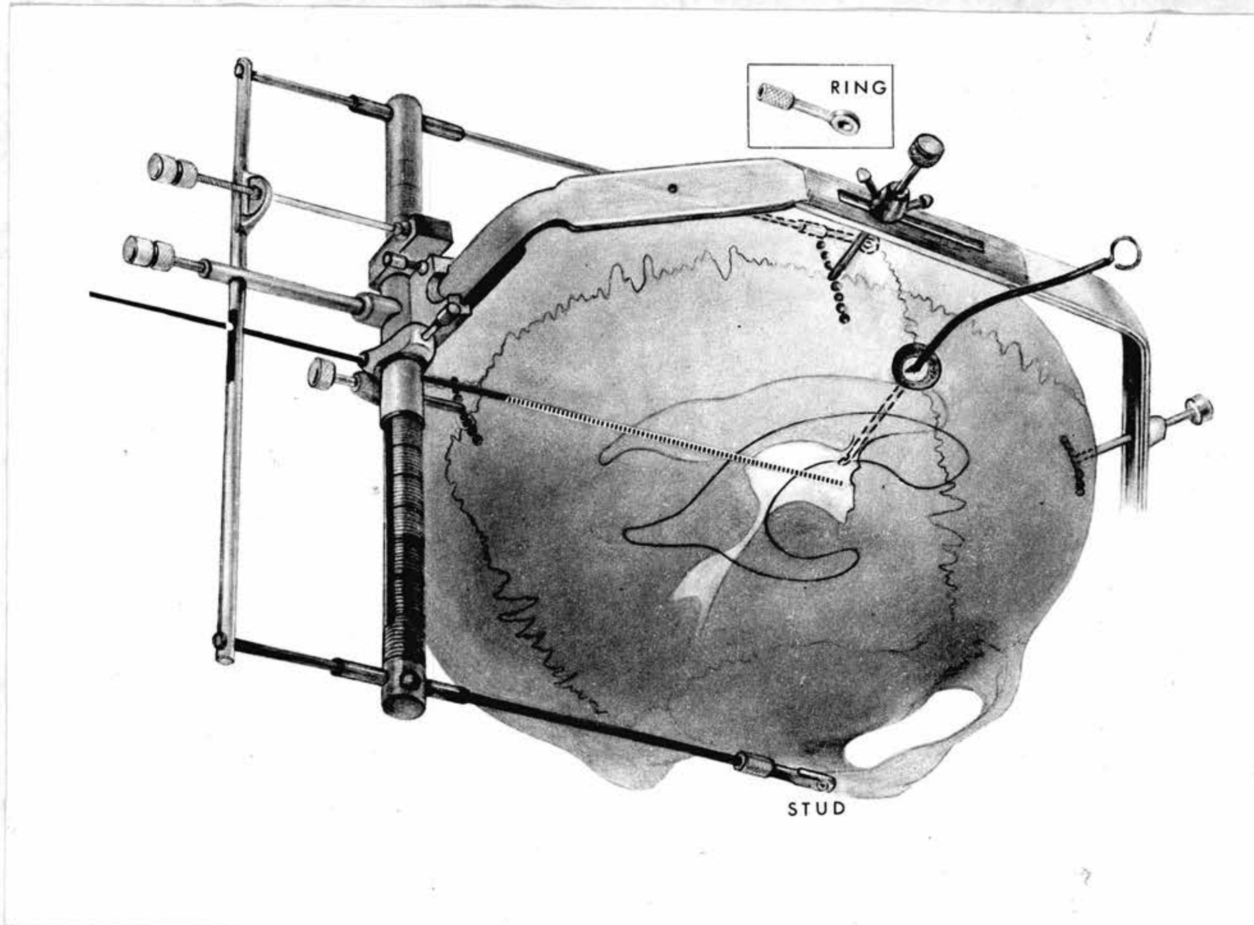


Fig.5. Central Brain Lesion. Insertion of Electrode using Stereotactic Frame.

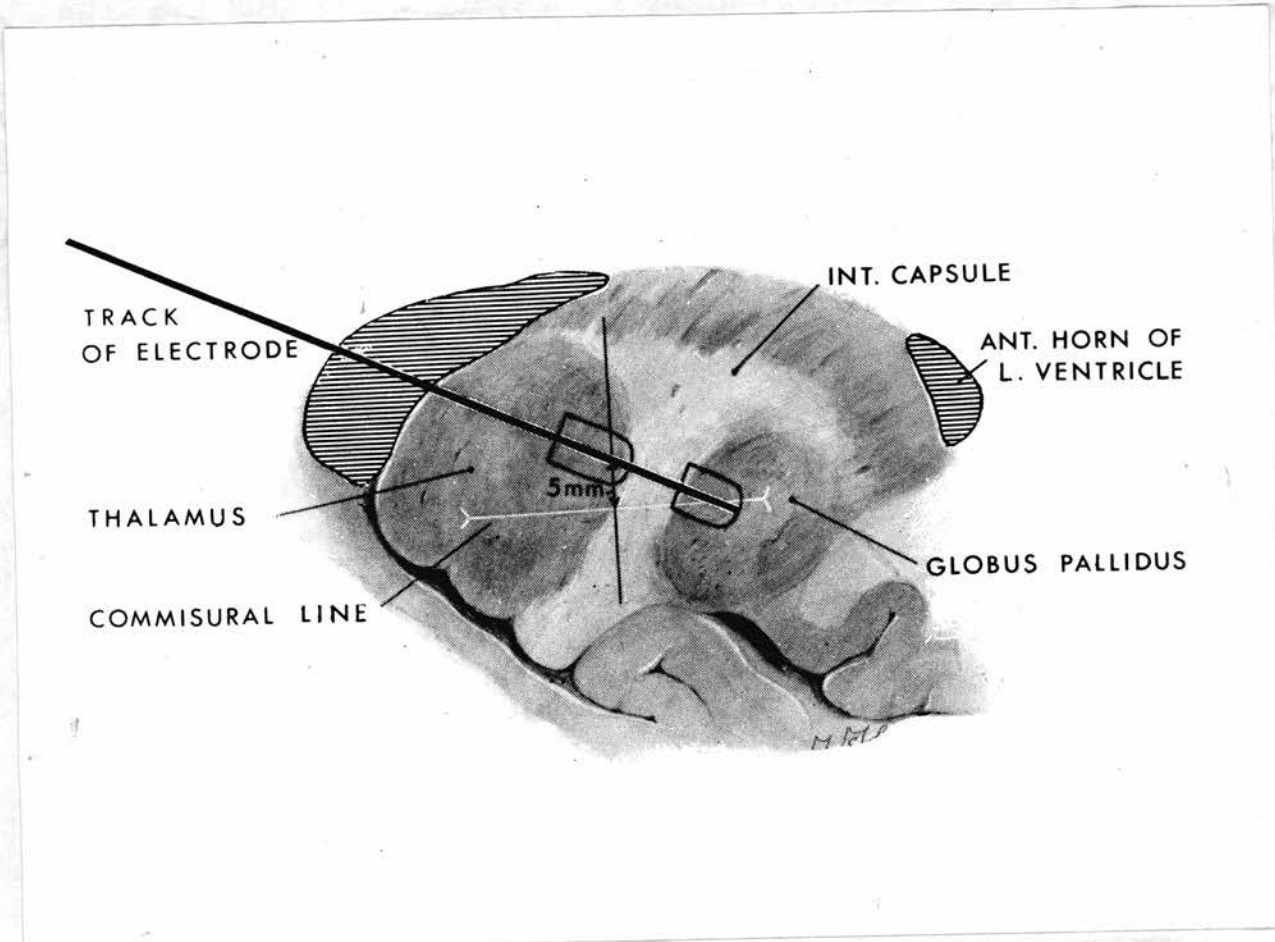


Fig.6. Central Lesion: Site & extent of lesion indicated by bullet shaped area.

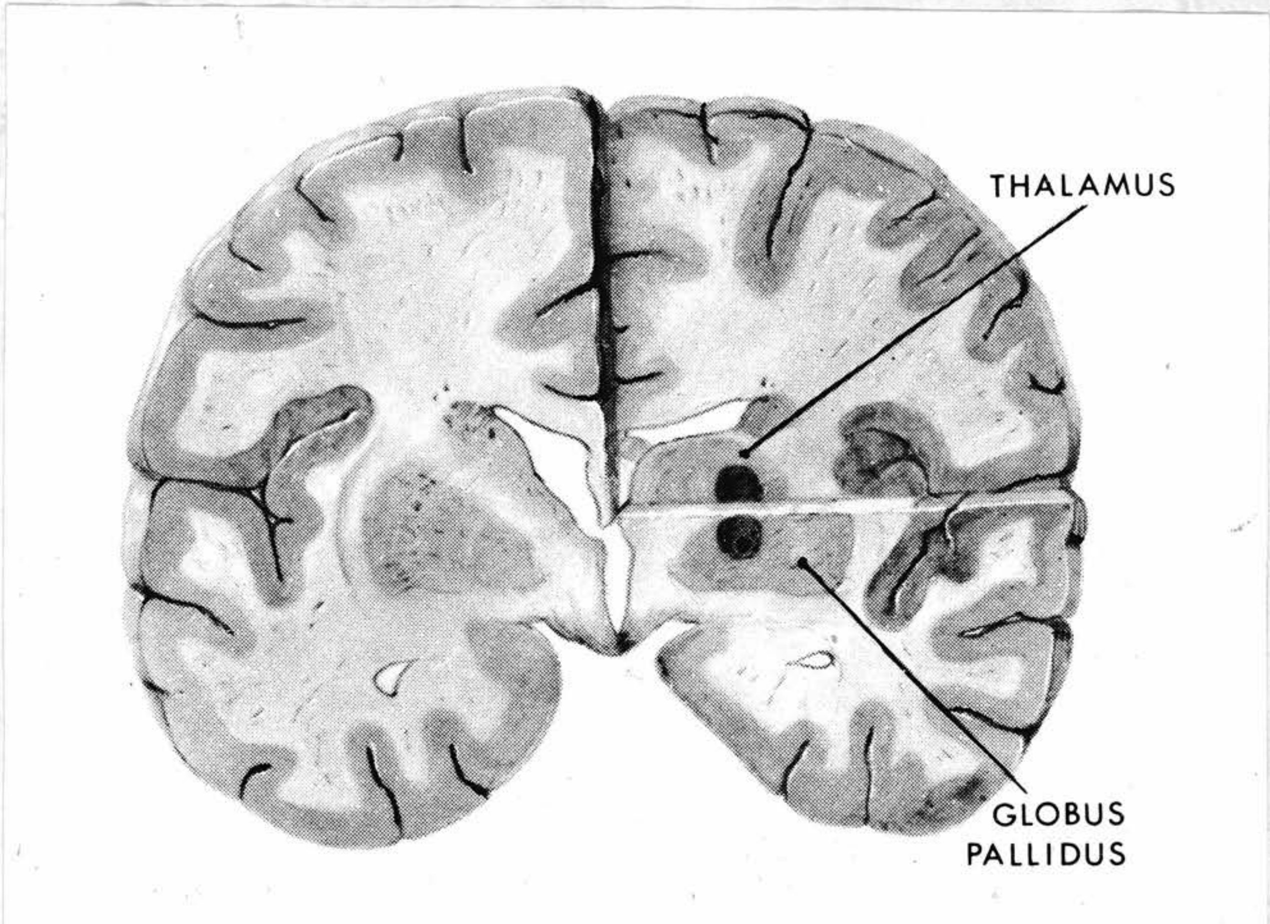
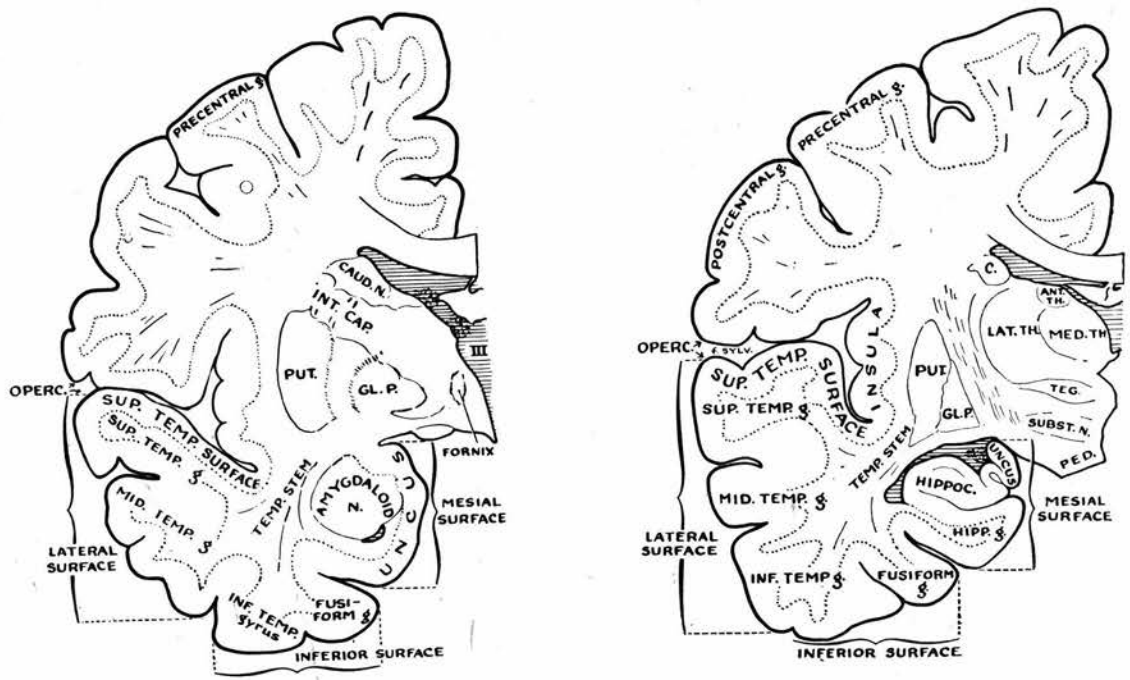


Fig.7(i). Coronal Section showing lesion sites in central areas of the brain.



Frontal transection (a) through the amygdaloid nucleus and (b) posterior to it. Superior surface (lower operculum) of temporal lobe is continuous with cortex of insula. Mesial surface is separated from superior surface by the temporal stem, but the two surfaces are joined, just anterior to the stem,

Fig.7(ii). Coronal Section showing lateral & mesial temporal structures.

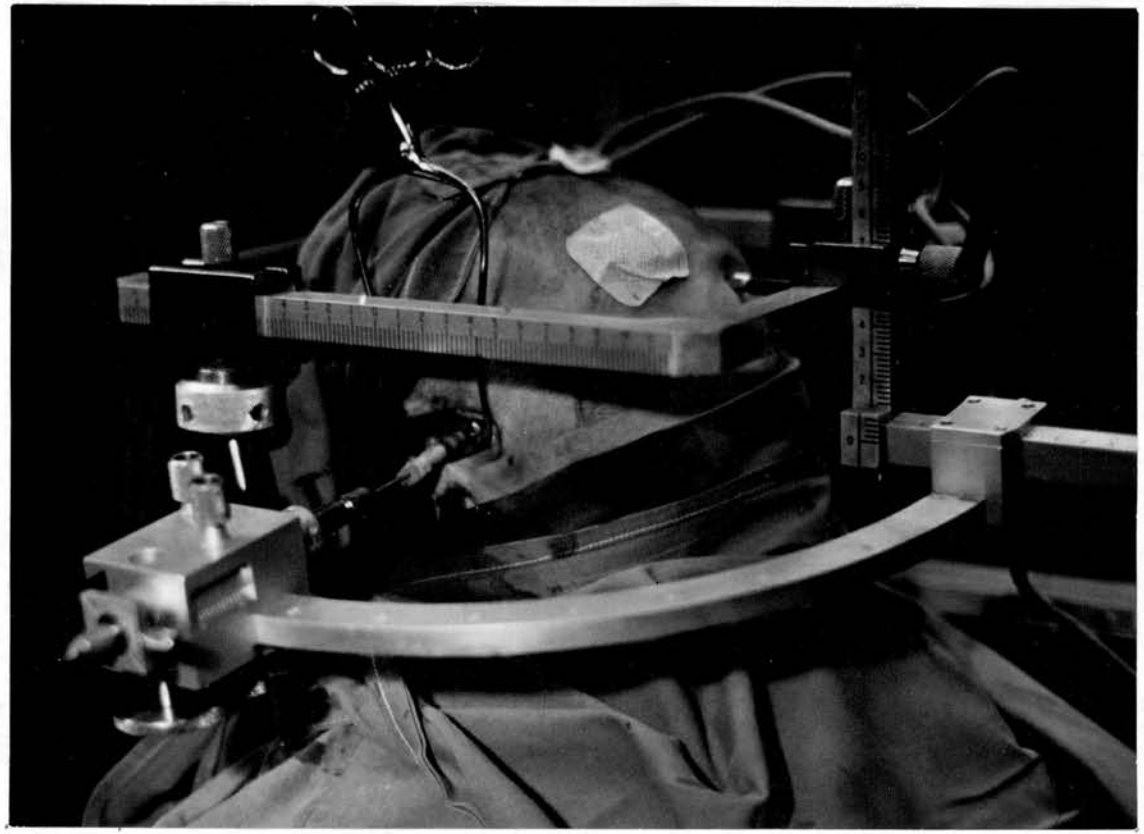


Fig.8. Amygdalotomy. Insertion of Depth Electrodes, using Stereotactic Frame.

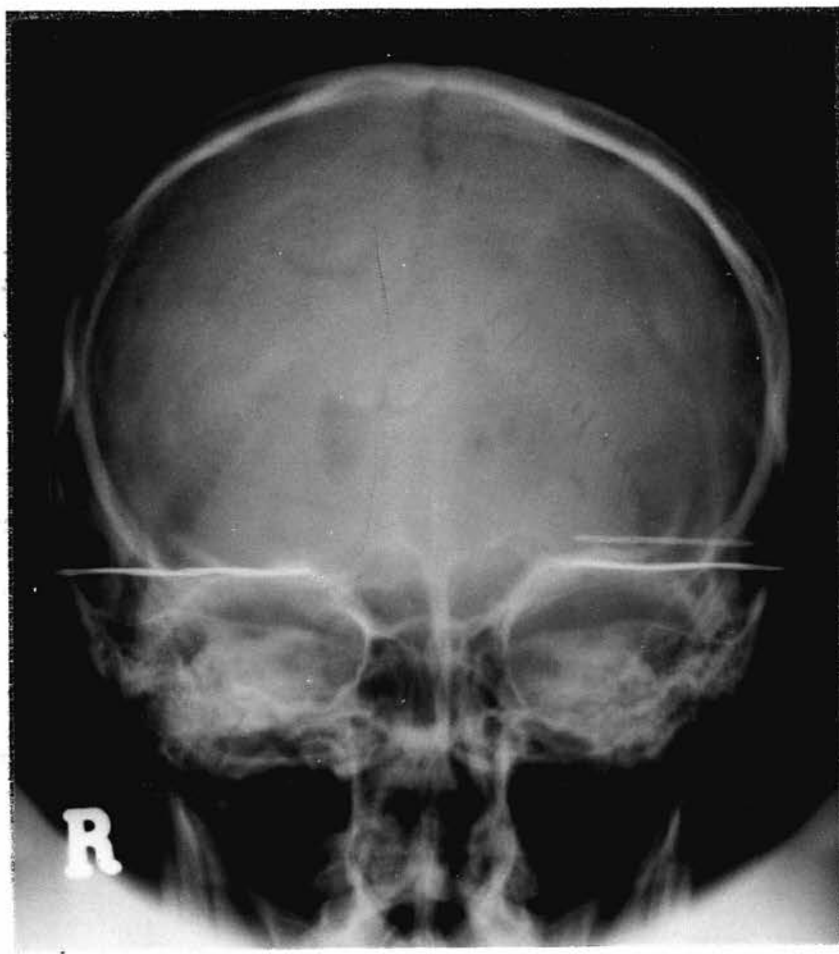


Fig.9. Amygdalotomy- Radiological Visualisation of Probe at Target.

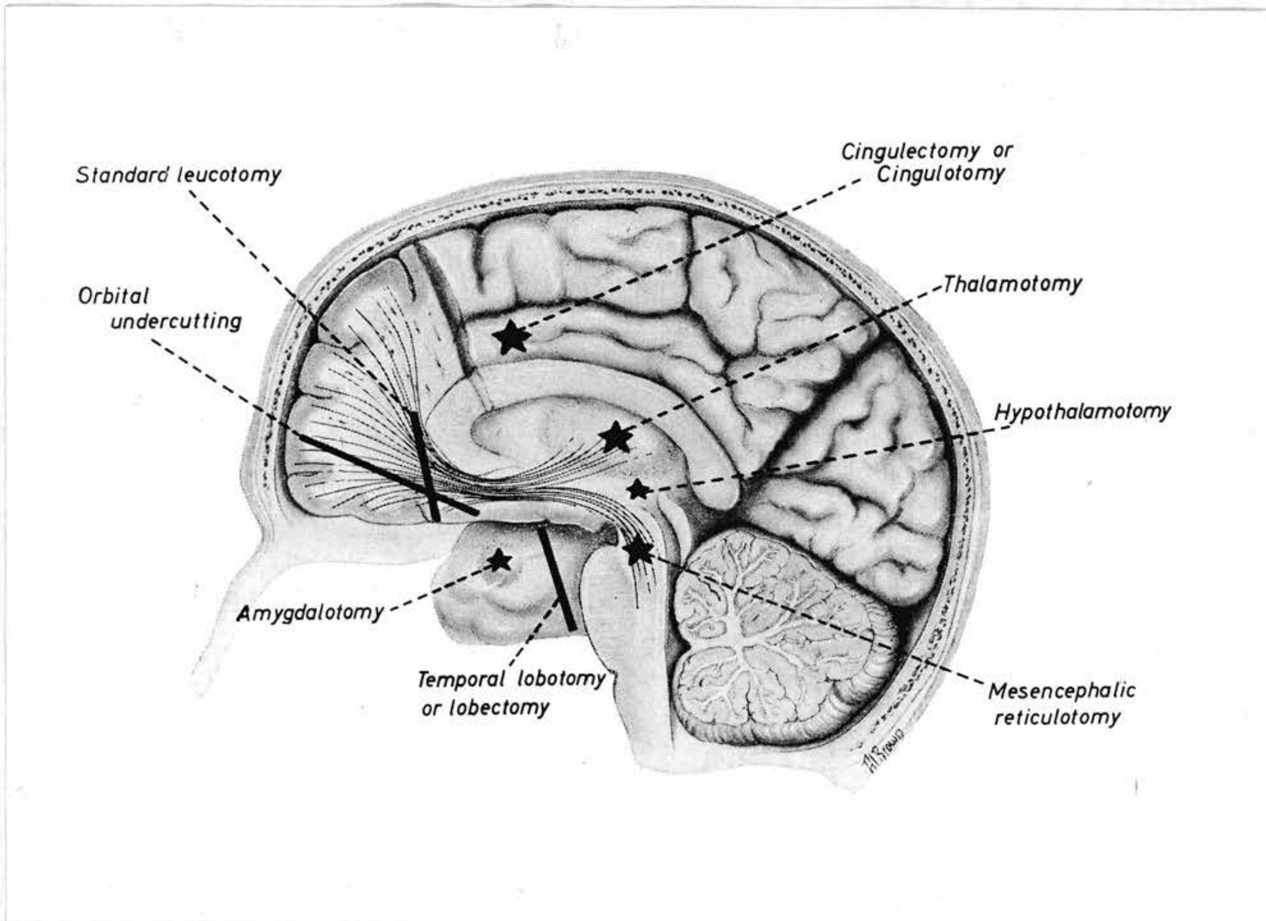


Fig.10. (with kind permission of E.R. Hitchcock.)

indicated that each surgeon was treating 2-3 new patients per annum, a rather lower figure than the one per month planned at the outset of the project. If this rate continued it would take four years to accumulate 50 cases.

If only 12 new cases per annum could be expected, then avoiding wasted or missed data became a high priority. One consequence of this was to rush the initial planning stages in order to "catch" cases pre-operatively. It soon became clear that neurosurgeons do not defer even elective surgery, to give the psychologist time to deliberate over suitable assessment techniques. Accounts of practical difficulties are not regarded as valuable in presentation of scientific work. However, the extent to which they are not overcome dictates choice of techniques and influences quality of data. In terms of experimental design, the specific problem was that the independent variable (surgical intervention) was not under the control of the experimenter (psychologist).

The situation partially resolved in the subsequent period, as the psychologist's assessment plan became more clearly formulated. It has been apparent throughout the study that the more the neurosurgeon is interested in the psychological effects of the surgical procedure the more the psychologist has been able to participate in decisions about timing of surgery and to communicate about assessment procedures. Thus much fuller data have been collected on some cases than on others. This is regrettable but probably unavoidable in a project such as this involving different disciplines and a number of individual consultants.

It was decided to assess cases as soon as possible after referral/

referral, with postoperative follow-up at one month, three months, six months, one year and subsequently annually.

In addition to the main study - pre- and post-operative assessment of patients undergoing surgical treatment of epilepsy - the study has extended in the following directions:

(1) The retrospective study already mentioned developed further than initially anticipated. Together with the cases in the prospective study, this forms a group of 352 patients with epilepsy undergoing neurological investigation in Edinburgh over the past 20 years. The majority of patients were assessed using the same tests of cognitive function, with adequate data available for analysis in 283 cases.

(2) A study describing personality and behaviour in patients with epilepsy undergoing neurological investigation in the Department of Surgical Neurology, Edinburgh over the past four years. This enables comparison of a sample of 121 patients with findings from published studies of other samples of patients with epilepsy.

(3) A study of the behavioural effects during electrical stimulation coagulation of the amygdala, in a small sample (6 cases).

(4) A study of reaction time and behavioural disturbance in a group of 31 institutionalised subnormal patients with epilepsy. This provided normative and reliability data from a group comparable in certain aspects with the neurological sample.

(5) A study of frustration tolerance. Data were collected on a sample of 22 student nurses in an attempt to validate measures made in situations designed to be mildly stressful or frustrating.

(6) The administration of a questionnaire on hostility to a group/

group of female students.(86)

3. Techniques used in assessment of psychological function

These are detailed in Table I. Not all techniques were appropriate for all patients.

A. Cognitive function. The four tests which had been used throughout the period of the retrospective study formed the basis of the prospective assessment of cognitive function. These are:

(1) Raven's Progressive Matrices

(2) Mill Hill Vocabulary Scale

(3) Graham Kendall Memory for Designs

(4) Sentence Repetition

At various stages during the study various tests have been added. The reasons for inclusion of these were:

(1) Evidence from related published studies of specific areas of deficit associated with epilepsy or brain lesions comparable with those in the current study. Examples of these are Porteus Maze Test, Verbal Learning, Delayed Recall, Perseveration and Word Fluency, Photo Recognition and Schematic Face Matching.

(2) To enable more direct comparison with results from other studies, the WAIS test was included.

(3) The Stanford Binet Test was included to enable assessment of intellectual function at levels lower than those meaningfully assessed by Raven's Progressive Matrices. The retrospective study indicated that there would likely be quite a number of such cases.

(4) Ad hoc testing - in an attempt to quantify data observed clinically (reaction time, orientation questionnaire).

The majority of these are standardised tests, administered in accordance/

TABLE I

SUMMARY OF PSYCHOLOGICAL ASSESSMENT TECHNIQUES

A. Tests of Cognitive Function

(i) General Intellectual Level

(a) Raven's Progressive Matrices	A test of non-verbal reasoning ability
(b) Mill Hill Vocabulary Scale	A test of ability for verbal communication
((c) Stanford Binet Intelligence (Scale	An age scale, measuring) intelligence)
((d) Wechsler Adult Intelligence (Scale. W.A.I.S.	Measure of intelligence)
(e) Porteus Maze Test	A paper and pencil performance test of foresight and planning capacity

(ii) Memory Function

(a) Graham Kendall Memory for Designs	Test of ability to reproduce simple, geometric designs from memory, immediately after presentation
(b) Sentence Repetition (Stanford Binet XI year Item)	Test of short term memory for verbal material
(c) Williams' Memory Scale:	
1. Digit Span	Test of short term memory
2. Non-verbal Learning (Rey-Davis)	This task requires the patient to learn the position of 1 fixed peg on each of 4 boards containing 9 pegs
3. Verbal learning	The patient has to learn the meanings of 8 new words
4. Delayed Recall	The patient is required to recall pictorial material seen 10 minutes previously
(d) Photo Recognition (Modification of Milner's test)	Test of ability to select, from 24 photographs of faces, the 12 which the patient was shown $1\frac{1}{2}$ minutes previously
(e) Orientation Questionnaire	

(iii)/

Table I cont'd.

(iii) Miscellaneous

(a) Word Fluency (Stanford Binet X year Item)	To pass this item the patient must say 28 words in one minute
(b) Perseveration	The patient is asked to draw 2 circles, a cross and a square
(c) Reaction Time	A measure of time to react to a light stimulus, by depressing a switch
(d) Educational Attainments 1. Burt-Vernon Reading Age 2. Vernon Arithmetic Test	

Table I cont'd.

B. Personality and Behavioural Assessment

(i) Questionnaires	
(a) Cattell's 16 Personality Factor Questionnaire	A multidimensional measure of 16 distinct primary personality factors
(b) Personality & Personal Illness Questionnaire (Foulds)	
1. Symptom Sign Inventory 2. Hostility & Direction of Hostility Questionnaire 3. Hysteroid-Obsessoid Questionnaire	Questionnaires measuring 3 levels of psychological functioning - symptoms, attitudes and personality
(c) 1. Eysenck Junior Personality Inventory 2. Eysenck-Withers Personality Inventory	Scales designed to measure the 2 major personality variables of neuroticism (or emotionality) and extraversion/introversion
(ii) Self-rating - Visual Analogue scale	The patient completes the scale daily, thus providing an index of change in self-rating, on such continua as Happy-Depressed and Well-Ill
(iii) Rating Scales and Checklists	
(a) Hargreaves Nursing Rating Scale	Designed for daily use by psychiatric nurses, covering a wide range of psychopathology, with 24 items each rated on a 10 point scale
(b) Adaptive Behaviour Scale	A behaviour rating scale for mentally retarded and emotionally maladjusted individuals, completed by nursing staff, teachers (and also by parents). Part I covers the individual's skills and habits in areas important in the maintenance of personal independence. Part II provides a measure of maladaptive behaviour, related to personality and behaviour disorders
(c) Checklist of observation of 10 minute samples of behaviour	The patient is observed and a list of behavioural items checked off

(iv)/

Table I cont'd.

(iv) Objective Measures

(a) Mirror Drawing	This task is designed to provide a measure of tolerance of frustration. (Time spent on task, and number of items attempted)
(b) Pursuit Rotor	On this tracking task, the patient has a number of trial runs, at different speeds. Then, he is encouraged to adjust the speed himself (providing a measure of choice of level of difficulty). Next, the speed is fixed at a moderate rate, and the buzzer switched off (feed-back). A series of false "success" readings are given, followed by a series of "failure" readings. This is alternated for dominant/non-Dominant hand and for several different patterns. This provides a differential measure of the patient's persistence when succeeding and failing.
(c) Gibson Spiral Maze (Modification)	The patient is required to trace a path through this circular maze, using his non-dominant hand. The test is administered under 3 conditions: 1. The patient is left alone to complete the task. 2. The patient is stressed every 15 seconds, to increase his speed. 3. The patient is stressed every 15 seconds, to increase his accuracy. 4. As for trial 1. Variation in time taken and number of errors provides a measure of reaction to a mildly stressful situation.

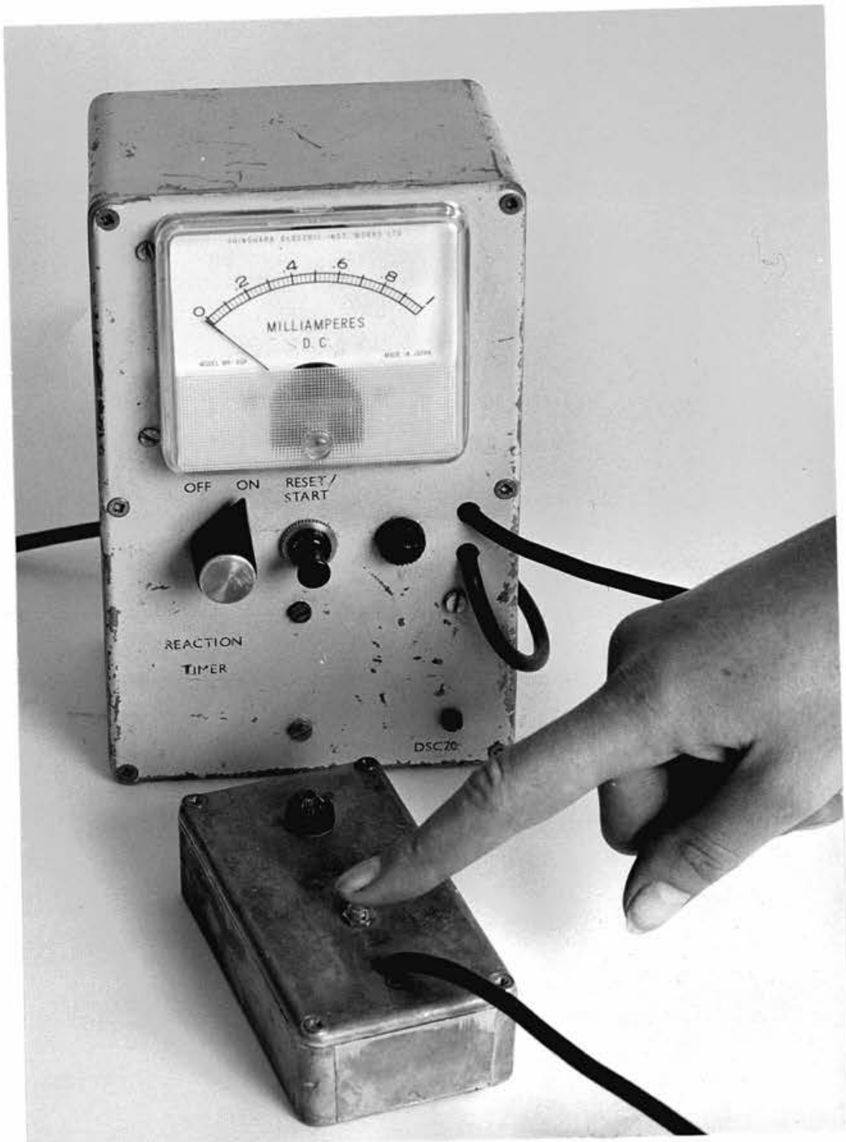


Fig. 11 Reaction Timer.

accordance with instructions and utilising appropriate normative data in published test manuals or journal articles. It is not considered necessary to give further details than in Table I, for such tests.

However, it is necessary to describe in some detail the method used in the Reaction Time Study:

Equipment

The apparatus is shown in Fig. 11. The stimulus is a standard instrument pilot light. The response is the patient's pressing a push button.

Condition A

The subject is given the following instructions: "You must hold your finger ready to press the button as soon as you see the light come on. I will give you a warning by saying, "Ready, now." Then the light will come on. You must not press the button until you see the light."

In this condition it is important to have a fixed fore period. A 2 second delay was chosen between the warning, "Ready, now" and the onset of the stimulus.

Method: The subject is instructed to start with his preferred (writing) hand. Three practice trials are followed by 5 proper readings. The subject is then instructed to change hands. Again 3 practice trials are given, and then 10 proper trials using the non-preferred hand. These are followed by a further 5 trials with the preferred hand.

Condition B

As in A, except that the fore period is varied from 0-5 seconds and readings are taken for preferred hand only. Condition B followed/

followed Condition A in the earlier parts of the study.

Condition C

This replaced Condition B in the later part of the study. Following Condition A, the subject was given the instructions, "From now on you will not receive any warning of when the light is going to come on. You must keep watching the box and press the button as soon as you see the light." Ten trials using only the preferred hand were carried out, with intertrial interval varying randomly from 10-40 seconds. This modification of the procedure was made in an attempt to measure one aspect of attentional processes. In this condition the task was related to a vigilance task.

Condition D

This condition was added at an even later stage and was less widely used. Following Condition C the subject was given the further instructions: "Now I want you to do something else as well. You have to keep watching for the light, and press the button as soon as the light comes on. At the same time I want you to count by 3s, out loud. That is, I want you to start with 1, add on 3, which gives you 4, plus 3 is 7." If the subject was unable to count in this way he was instructed to count by 2s.

A further 10 trials were made, again using dominant hand and again with intertrial interval varying, this time from 5-20 seconds.

This provided a measure of subjects' reaction time under distracting conditions.

Treatment of results

Means and standard deviations of time to react to light stimulus were calculated for each hand separately for Condition A and for Conditions/

Conditions B, C and D (where available). This enables comparisons to be made of an individual's performance on one occasion, under different conditions, across occasions under the same condition and also comparisons between individuals.

B. Personality and behaviour. Prior to 1969, psychological assessment of cases of epilepsy followed the pattern of assessment of other neurological cases. This included, routinely, the four tests of cognitive function indicated earlier, and also the Rorschach Inkblot Technique. Some studies have evaluated postoperative change through responses to projective material (Jurko and Andy, 1973). However, it is difficult to quantify data of this type (particularly where a free rather than a multiple choice response is used).

It was decided to use personality questionnaires, rather than projective techniques in the prospective study, for those cases functioning at an effective enough level for this method of investigation to be appropriate. The questionnaires selected are listed in Table I, Section B(i). For some patients it was necessary to complete the questionnaire orally. Questionnaires were administered and scored in accordance with manual instructions. The two most frequently used were 16 P.F. and HDHQ.

These questionnaires ask how the person acts or feels in or what his opinion is about various situations. It is not claimed that the responses to these particular questions reflect the individual's actual behaviour in the specific situations in question. What is claimed is that individuals whose responses to these questions follow a similar pattern can be described as being of the same type, or as exhibiting the same degree of a particular trait or fitting whatever the/

the theoretical structure of personality adhered to by the psychologist designing the questionnaire. Depending on the studies completed in validating the questionnaire, greater or less caution is required in utilising this data to predict how the individual is likely to behave. Construction of questionnaires, as any other test, requires information not only about what the test is measuring, but also how consistently it measures (reliability). Of particular importance, in selecting techniques for use in a pre/post treatment design as in the present study, is information about test/retest reliability. How accurately does the test detect real changes in an individual across occasions of administration?

Both questionnaires and projective techniques have been widely criticised in terms of validity and reliability. Such inadequacies are discussed in most textbooks covering the area of personality assessment (Hilgard et al., 1971). The concept of personality as enduring tendencies to act consistently across situations, has been reviewed (Mischel, 1968).

In the present study questionnaire results are considered only where there is adequate test/retest data, and as indicated earlier, the questionnaire is taken as measuring what it is claimed by its designers to measure. No claim is made that all aspects of the individual's unique adjustment to his environment are covered by the chosen tests.

Awareness of the above limitations of the questionnaire method, together with limitations imposed by both personality questionnaires and projective techniques' dependence on verbal responses, led to the search for additional ways of looking at patterns of behaviour.

Another/

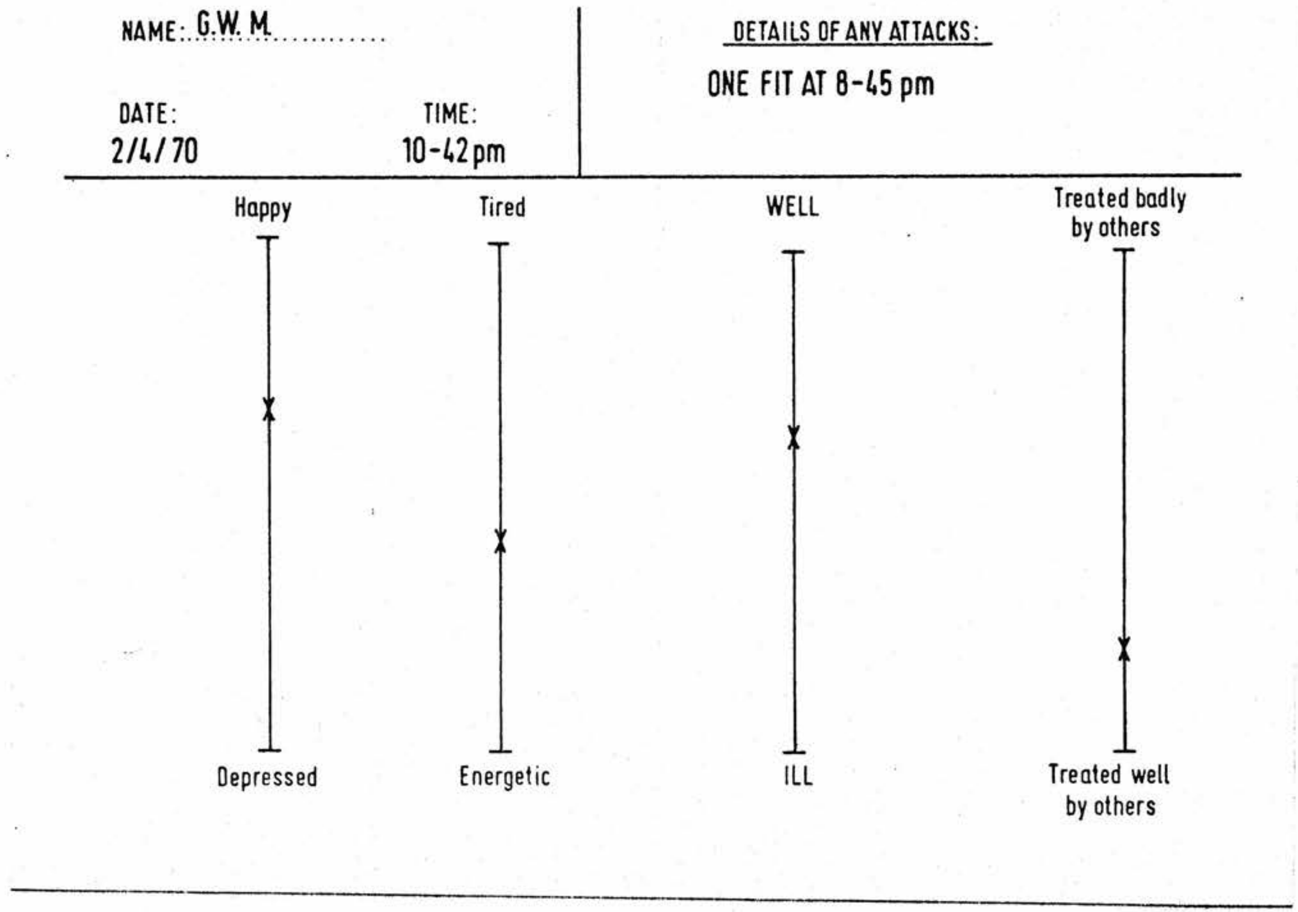


Fig.12. Visual Analogue Scale.

Another form of self-report technique was found. This was described by Zealley and Aitken (1969), as the Visual Analogue Scale (B(ii)). These authors used a 10 cm. line, used to provide a unipolar measure of depression. The patient records how he feels at the time by marking a cross at some point along the line, one end of which is marked "Depressed." In the present study a sheet, as in Fig. 12, was presented to the patient. This contained four bipolar lines initially, to which a fifth one was added - Relaxed-Tense. Instructions to the patient on how to complete the scale are given at the top of each sheet. It is completed daily if possible for one or more weeks at a time, either at home or in hospital. This scale was included because (a) it is simpler and quicker to administer than personality questionnaires and, as Zealley and Aitken indicated, can be given repeatedly to the patient without the same risks of boredom and fatigue which a long questionnaire involves. In addition it was considered very important to obtain information about day-to-day variation in patients' mood pre- and post-operatively.

Many patients were too dull or too disturbed to answer personality questionnaires or to complete a line-marking scale meaningfully. In all patients, however, behaviour can be observed and can be quantified.

A variety of <u>observation methods</u> (B(iii)) has been used. The more direct the recording of ongoing behaviour the more satisfactory the results obtained. However, it has also been necessary to utilise extensively other checklists and rating scales which necessitate the rater scanning a fixed period of time during which the patient has been observed. The rater must make decisions about whether a specified/

specified behaviour occurred or not, or decision about the extent to which the specified behaviour occurred. Copies of checklists and Rating Scales used in the study are included in Appendix 2.

Use of the Hargreaves Nursing Rating Scale was restricted to cases who were hospitalised elsewhere before and after admission to the Department of Surgical Neurology. This rating scale was used most extensively on the few patients undergoing stereotactic amygdalotomy for which a much more detailed systematic procedure of investigation (including psychiatric and biochemical studies)has been developed. (These procedures are described in joint papers which were presented at the second and third International Conferences in Psychosurgery (Hitchcock et al., 1972, 1973). Copies of these papers are included in Appendix 5).

In this group, patients are admitted for one month before and after surgery to a small research unit in which the relatively high nurse/patient ratio enables more detailed methods of observation/ assessment of patients by the nursing staff. Since the introduction of the Hargreaves Scale in connection with the MacRobert Epilepsy Project, its use has been extended to a number of other patients in the Brain Metabolism Unit. This has been particularly valuable in providing training and experience in the use of the scale, which is essential in improving reliability. Unfortunately, this has not been feasible where the Hargreaves Rating Scale has been used in understaffed chronic wards of other psychiatric hospitals. Nursing staff have been extremely co-operative, but the opportunity for evaluating inter-rater reliability by having duplication of ratings on the same day, has not occurred often; nor are these raters having the/

the experience of using the scale with other than MacRobert Project patients. This seemed an unreasonable burden to impose on an already overworked nursing staff. This has also been the reason for failure to develop adequately the third observational method, that of recording ongoing behaviour over short periods of time (5-10 minute samples). This method was introduced early in the project but very inadequate samples (1 x 10 minute per day) were being collected at that stage. Recently this method was applied in one case (again during inpatient assessment in the Brain Metabolism Unit). Two consecutive five minute samples were recorded at intervals throughout the day, providing approximately one hour of observation daily for a period of one month pre- and post-operatively. This method is particularly useful in cases where the Hargreaves Scale is less appropriate, e.g. with some severely subnormal patients, or hyperactive children. A copy of the record sheet devised specifically for this individual patient is included in Appendix 2.

The ease with which the Adaptive Behaviour Scale can be completed has led to extensive use, particularly of Part II (Maladaptive behaviour). Originally designed for use with institutionalised subnormal patients in America, it has proved useful for a large number of patients, especially where it has not been possible to arrange a period of inpatient assessment, or again where use of the Hargreaves Scale is less valuable.

Data were collected on Part II, on a sample of 35 patients with epilepsy (in an Edinburgh subnormality hospital) as part of a study of the effects of folic acid. In the Results section, this group is sometimes referred to as the "Gogarburn group."

Within/

Within the neurological sample (prospective study) Part II has been completed by relatives, teachers, Occupational Therapists, as well as by nurses. Those familiar with the patient are asked to complete the checklist, based on the patient's behaviour over a fixed period of time (e.g. past 3 months). If an item of behaviour is endorsed, then it must be rated as either a frequent or occasional occurrence. For each patient as many different people, representing as many different situations as possible, are asked to complete the scale and this is repeated.

An alternative approach to recording what behaviour happens to occur, is that of setting up specific situations designed to elicit certain behaviour. The three tasks described as "Objective Measures" (B(v)) fall into this category. These are a more recent development in the study. The tasks were designed to be mildly stressful or frustrating.

A detailed discussion of rationale and technique is required, and this, together with some indications of validity and reliability obtained from a normative group (student nurses), is contained in a separate report - Appendix 1.

The only technique remaining to be described is the stimulation study. For 6 of the patients who underwent amygdalotomy under local anaesthesia the effects of stimulation and coagulation were recorded in detail with the use of a tape recorder. The surgical procedure involved the bilateral stereotactic placement of electrodes within the amygdala. Stimulation was carried out as the probe advanced toward the target at various points short of target, on target and occasionally beyond target. Our stimulus parameters are comparable with/

with those of other studies, cf. Chapman (1958), 5-100 Hertz, pulse width 1 millisecond, voltage ranging from 1 to 10 using a Radionics thermoprobe electrode with exposed tip dimensions 3 mm. x 1.8 mm. Where it was feasible stimulation was repeated to ensure that the response obtained was not an artefact of the situation but where extremely aggressive responses were being obtained and the patient was becoming disturbed it was not considered desirable to repeat these more than was absolutely necessary for localisation purposes to identify the target area.

Having concluded the description of the techniques, it is now appropriate to turn to a consideration of the patients to whom the various techniques described above were applied. Not all methods were applicable to all patients. Even where methods were applicable, there were numerous instances in which practical difficulties precluded administration.

4. Patients studied

Over a four year period from July 1969, psychological assessment was carried out on a total of 121 patients undergoing neurological investigation of epilepsy. The majority were either inpatients in the Department of Surgical Neurology, being considered for surgical treatment, or review cases seen as outpatients. However, any patient with a provisional diagnosis of epilepsy was eligible for inclusion. Selection was only in terms of availability for psychological testing. To minimise the risk of obscuring real differences between epileptic and non-epileptic and between psychomotor and non-psychomotor patients it was decided to use either clinical or electroencephalographic evidence. Thus, the "epileptic" category included anyone in whom frank fits/

fits were not verified but in whom the EEG was indicative of epileptic abnormality, as well as those with seizures. If any past or present EEG findings indicated a temporal lobe disturbance and if, in the absence of EEG evidence there was an indication of psychomotor seizures, the patient was classed as within the temporal lobe epilepsy category. There are 63 cases in this group and 48 cases of epilepsy in whom there was no evidence of temporal lobe involvement. Cases where the only manifestation was of outbursts of aggressive behaviour were not included. There were 10 such cases, all referred by psychiatrists for investigation of the possibility of epileptic phenomena. Of the 121 patients, 71 underwent surgery. Some of these cases underwent surgery before the current scheme of psychological assessment was fully developed; other cases were not available for assessment prior to surgery; similarly, assessment was incomplete on a number of non-operated cases; and since, as already indicated, not all techniques of assessment were applicable to all cases, numbers were further reduced in considering any particular aspect of data obtained. For each of the three main operative groups (unilateral temporal lobectomy, stereotactic central lesions and stereotactic amygdalotomy) adequate data were available on 10-15 patients.

It must be noted that the retrospective cases may represent a slightly different sample insofar as (a) old cases are classified according to diagnosis on discharge and hence cases of symptomatic epilepsy are filed in accordance with underlying pathology rather than under "Epilepsy." Hence they tend to be excluded from the retrospective study; and (b) the retrospective sample consists of cases referred for psychological assessment while in the prospective study/

TABLE II (a)

Data on 121 cases	SEX		TYPE OF EPILEPSY			Age of Onset				Age at assessment					
	M	F	Temporal lobe Epilepsy	Non Temporal lobe epilepsy	? or non Epilepsy	0–10	11–20	21+	? or non	0–10	11–20	21–30	31–40	41–50	50+
Non-operated cases (50)	34	16	17	26	7	14	21	8	7	4	22	12	5	4	3
Operated cases (71)	48	23	46	22	3	40	17	11	3	8	29	17	11	5	1
Total (121)	82	39	63	48	10	54	38	19	10	12	51	29	16	9	4

TABLE II(b)

Psychiatric Status of 121 Patients

Description	Number
1. Normal	24
2. Mentally Retarded (a) without behaviour disturbance (b) with behaviour disturbance	 9 29
3. Some evidence of neurotic disturbance or personality disorder	44
4. History of, or presence of psychotic disturbance	15
Total	121

TABLE II(c)

Age at operation and sex in 3 main operative groups

Type of operation and number of cases	Sex M	Sex F	Age Mean	Age Range
1. Central Lesions (13)	9	4	27.2	13-48
2. Amygdalotomy (19)	14	5	24.1	6-44
3. Temporal Lobe Excisions (28)	15	13	22.9	7-52

T A B L E II(d)

Analysis of Neurosurgical Procedures (71 Cases)

Operation	Unilateral	Bilateral	Total
Stereotactic 'central' lesion (target sites include thalamus, pallidum, internal capsule)	3	8	11
Stereotactic Amygdalotomy	3	15	18
Stereotactic central lesion + Amygdalotomy	1	-	1
Temporal Lobectomy - right left	13 10	- -	13 10
Stereotactic central lesion + temporal lobectomy	1	-	1
Amygdalectomy	1	4	5
Other Cortical Excisions			6
Cingulectomy			1
Shunt Procedures			3
Hemispherectomy			1
Craniotomy only			1
Total			71

study, in addition to referrals, any case with a provisional diagnosis of epilepsy was eligible for inclusion.

Table II gives information about numbers, sex, age, epilepsy and surgical procedures in the main areas of the study.

5. Design of study

(a) It did not seem feasible to adopt the conventional approach of carrying out a pilot study since the rate at which data accumulated was likely to be very slow. Furthermore, since the sample of patients could not be defined in advance it would have been irrelevant to conduct a pilot study to evaluate techniques on a control non-surgical group. Some indications were obtained from the retrospective study and these are discussed in the section on results.

(b) In the main area of the study - psychological effects of different surgical procedures - concern is about intra-individual changes over time. This type of pre/post treatment study lends itself to a design using each subject as his own control. Ideally a series of assessments is carried out, interrupted at one point of time by the surgical procedure. It is only possible to use this design if an adequate pre-treatment baseline can be established. This is particularly difficult in cases liable to episodic fluctuation in behaviour and pattern of functioning.

It was not considered essential or desirable for all cases to undergo the month's inpatient assessment, in a special psychiatric unit, which was organised for cases undergoing amygdalotomy. The rating scales and checklists completed daily during this period were designed to cover aspects of disturbed rather than normal behaviour. However, it would have been preferable to have daily ratings for all cases/

cases in whom there was a history of disturbed behaviour or evidence of disturbed behaviour during initial outpatient appointment. It was essential if any attempt was to be made to correlate behavioural disturbance with the occurrence of seizures.

Not all consultants responsible for the management of patients could be convinced of the value of such periods of assessment, nor of the need to control extraneous variables such as medication. In some cases it was possible to arrange preliminary assessments immediately after initial referral to the neurosurgeon, and to have a period of several months during which assessment procedures could be repeated. Where this is so, the study is a more adequate one. Unfortunately, in a large number of cases brief psychological assessment (consisting of tests of intellectual function and perhaps a personality questionnaire) was all that could be carried out on the day or two before surgery.

At the outset it was assumed that the decision to use each subject as his own control settled the design issue. The fallacy of such an assumption is dealt with more appropriately in the discussion of the study.

(c) It was recognised that there were many extraneous variables liable to distort results (unavoidable changes in medication, changes in the patient's social and physical environment, expectations from surgery). In addition there were two independent variables to be considered. These were the surgical procedure itself and the possible resultant change in seizure pattern. The ease with which the first could be identified (as an event in time and neuro-anatomical space) contrasts with the difficulty in evaluating the second with any degree of precision. Of course, the occurrence of the second is <u>dependent</u> on the/

the occurrence of the first. However, in terms of psychological function, both must be regarded as variables influencing performance. In practice, seizure frequency was monitored and the decision taken that where significant changes in psychological function occurred postoperatively, variation in seizure frequency would be considered in evaluating results. The main aim of this study is investigation of the psychological effects of the surgical procedure, not of seizure pattern in relation to psychological function.

(d) Two separate sets of hypotheses were to be tested in the main study. The first required measurement of change within the individual. Then such changes in individuals would be grouped together according to type of surgical procedure, in order to test the second hypothesis which was that these groups could be discriminated on the basis of changes which had occurred following surgery. Furthermore, it would be desirable to test that such discrimination was also possible between these groups and groups of comparable cases in whom there had been no neurosurgical intervention. Assigning referred patients randomly to "operation" or "no operation" categories was rejected on ethical grounds (although such sham operations have been reported, in the Columbia-Greystone Project, by Mettler in 1952).

In the present study there was another less perfect method, not using matched controls, but providing a group still useful for comparative purposes. A number of referred cases, on whom preliminary psychological assessment had been carried out, did not come to surgery. (Reasons for this included a decision against surgery by the referring psychiatrist or others involved in the patient's management, the patient becoming institutionalised outwith the catchment area, and postponement/

postponement of admission to the neurosurgical unit). Whenever possible repeat assessments at appropriate time intervals were carried out on these cases, thus providing a measure of change over time in the absence of surgical intervention.

There were a further two cases in whom the surgical procedure was only an exploratory one and no excision or lesion was made (in one case this was due to technical difficulties, in the other to failure to demonstrate abnormal electrical discharge with recordings from depth electrodes). Detailed pre- and post-"operative" psychological assessments were available for both. These two cases might be regarded as a better basis for a control study than the above group, except insofar as the neurosurgeon's decision not to proceed with the complete procedure in these particular cases might indicate some biassing factor. Both patients considered that they had undergone an operation, although it was explained that the surgical procedure had been less extensive than originally indicated.

Test/retest data were also available for the group of institutionalised subnormal patients with epilepsy, on two assessment techniques - Reaction Time and the Hargreaves Nursing Rating Scale.

(e) In the retrospective study and in the secondary areas of the study, concern is with comparisons between groups differentiated on some criterion (e.g. type of seizure, age of onset, type of treatment) and many of the problems of design associated with the main study do not arise.

<u>6. Treatment of results</u>

<u>(a) Retrospective study and secondary areas of the study</u>

Two types of analysis would be carried out in this part of the study/

study. The first would be to test the deviance of the sample in question from the expected distribution or from normative samples. The second would be to test the difference in performance between groups in the study.

Choice of statistical test was determined as follows. Where means and standard deviations based on raw scores provided an appropriate description of the groups, these would be compared using either an analysis of variance technique (F Ratio) or measure of the significance of the difference between two means (t test).

Interpretation of raw scores obtained on Raven's Progressive Matrices and Mill Hill Vocabulary Scales is based on age norms and it was decided to use the grading system based on percentile ranks provided by Raven (1960). Cases within each group being compared, were then assigned to categories (Grade I-V) and the data could then be treated by the appropriate X^2 (chi-square) technique. Where, for any particular test a method of comparison of group results was provided by the test author, this would be used. Cattell et al. (1970) provide a method for comparing group profiles on the 16 P.F. This uses weightings of the sten scores obtained on the sixteen primary factors, and enables the degree of correlation between two profiles to be calculated.

(b) Main study - pre- and post-operative assessment

While postoperative follow-up was designed to provide regular information about a patient's progress, it was decided to use a dichotomous classification in analysis of results. Three months was chosen as a cut-off point. Results obtained within 3 months of operation would be included in the short-term category, while those obtained more/

more than 3 months postoperatively would be included in the long-term category. In the main study emphasis was on individual changes. Where data were adequate these would be analysed separately as short-term and long-term changes.

There has been much discussion recently about the use of parametric methods with data where assumption about normality of distribution and level of measurement at least on an interval scale cannot be made (Chassan, 1967; Plutchik, 1968; Gottman, 1973). Often authors use parametric methods without any discussion of appropriateness (e.g. Hargreaves, 1968). Siegal (1956) has pointed out that using parametric methods where the assumptions are not met, is more likely to result in the null hypothesis being rejected when it is in fact true (a Type I error). .In the areas of the present study, which is investigating the therapeutic effect on disturbed behaviour, it is most important to avoid a Type I error; that is, to avoid interpreting a postoperative change in behaviour as significant when no real change has occurred.

Where the concern of the study is (as in studying cognitive function), to monitor performance in order to detect any unwanted side effects, it is extremely important to avoid accepting the null hypothesis when it is not true (a Type II error); that is, to interpret results as showing no deterioration when in fact some decline in level has occurred.

Selection of appropriate statistical procedures has been based to some extent on the above considerations.

Payne and Jones (1957) provide a method for evaluating the significance of changes in an individual's score on tests for which adequate/

adequate test retest data on a normative group are available. This could be utilised in evaluating individual changes in performance on Raven's Progressive Matrices and Mill Hill Vocabulary Scale (using raw scores, not percentile ranks as above).

Where in an individual patient repeated measurements have been made, these measurements can be considered as constituting two samples - one of behaviour pre-operatively, the other behaviour post-operatively. These two samples can then be compared to find if they are drawn from the same population - in this case "population" represents total pre- and post-operative behaviour, measured by the test in question. This method is applicable to the Reaction Time study, Visual Analogue Scale, Hargreaves Nursing Rating Scale and behavioural observation. In the former two the statistical test applied would be a 't' test, while in the latter two, dichotomous categories were used and a X^2 test would be applied. This is the only appropriate method for the behavioural observation technique in which items were checked as either occurring or not occurring. It had originally been intended to utilise all the information available from the 10 point rating scale of each item on the Hargreaves Scale. In a previous analysis this was treated as providing an interval level of measurement and a 't' test applied (Hitchcock and Cairns, 1973; Appendix 5). However, on reconsideration it was decided that this was not the most appropriate method and at the risk of some loss of information it was decided to categorise the data, as an alternative method of analysis. Only two categories could be used in this method, since there was interest in direction of change, if significant change was identified. If more than two categories were used difference/

difference could be identified between pre- and post-operative samples of behaviour, still using X^2 technique, but direction could not necessarily be specified. Where the total sample of expected cell frequencies was too small for the X^2 test to be applicable, the Fisher test for small groups (Siegal, 1956) would be used. (This uses data cast in the same way as X^2). A further consideration arose in considering data obtained by repeated individual measurement pre- and post-operatively in that these data form a time series and trends over time might distort the results obtained by considering the data as independent samples. It was decided to employ a simple method of visual inspection for trends, by plotting daily ratings for each individual.

For all the assessment methods described above and others used in the study, results could also be considered for groups. Various approaches could be adopted. The individual change scores obtained could be grouped, and differences between group scores evaluated. Alternatively, individual change scores could be evaluated and the group described in terms of the number of cases showing significant changes, as well as indicating the direction of the obtained changes. This again enabled comparisons to be made between different groups. A third method is the more common approach to the comparison of groups - to take the distribution of scores obtained by one group and compare this with the distribution of scores in another group or groups using either an analysis of variance technique (F Ratio) or a 't' test. The particular technique chosen is described as results are given.

In all aspects of the study in which statistical analysis was undertaken/

undertaken, a 0.05 level of significance would be accepted. Two-tailed tests would be used, but where the original hypothesis had indicated direction, the meaning of the obtained significant results would be considered to see if the expected direction was confirmed.

(c) On some aspects of the study where insufficient data were available for statistical analysis, descriptive results would be included, as would be the case with the stimulation study which did not lend itself to statistical analysis.

This concludes the description of the study undertaken. It is now appropriate to move on to a consideration of the results obtained through the application of these methods.

RESULTS

RESULTS

"....and since the properties of number appear to have the power of leading us toward reality these must be among the studies we are in search of"

(Plato)

1. Retrospective study. Cognitive function in epilepsy

The intellectual level of a group of 338 patients who have undergone investigation of epilepsy in the Department of Surgical Neurology over the past 20 years is shown in Table III. This group shows an abnormally high proportion of cases at lower levels of intellectual function (Table IIIb). Wherever possible the test used was Raven's Progressive Matrices. In a few very young or very dull cases the Stanford Binet Intelligence Scale was substituted. Within the total sample, it was useful to compare the intellectual level of the cases who were selected for surgical treatment first with the rest of the sample and then with a group of non-operated cases, matched with the operated* cases for age of onset of epilepsy, age at time of testing and sex. There was an overall difference in the distribution of scores on tests of intellectual function between these groups (Table IIIa), but the matched non-operated cases (106) and the operated cases (55) are shown to be similarly distributed. Since there was interest/

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* The word "operated" as used in this part of the study refers to the group of patients who subsequently underwent surgical treatment. The test results, however, are based on pre-operative assessment.

T A B L E III(a)

Intellectual Level of 3 Groups
(Based on scores on Raven's Progressive Matrices or Stanford Binet Intelligence Scale)

	Above Average	Average	Below Average	
	75th%ile	74-25 th	< 25th%ile	
Non-operated cases - total	47	95	141	283
Non-operated cases - matched	11	35	60	106
Operated cases	2	16	37	55
	[illegible]	[illegible]	[illegible]	[illegible]

* $x^2 = 8.23$ d.f. $= 3$ $p < .05$

T A B L E III(b)

Deviance of total sample - General Intellectual Level

	Above Average	Average	Below Average
	75th%ile+	74-25th	<25th%ile
Obtained Distribution	49	111	178
Expected Distribution	84.5	169	84.5

$x^2 = 54.75$ d.f. $= 2$ $p < .001$

TABLE III(c)

Raven's Progressive Matrices (R.P.M.) - Deviance of Matched + Operated Cases (161)

	Matrices Grade			
	I & II	III	IV	V
Obtained Distribution	13	52	50	46
Expected Distribution	40.25	80.5	32.2	8.05

$X^2 = 56.1$
d.f. = 3
$p < .001$

TABLE IV(a)

Raven's Progressive Matrices Comparison of 55 Operated Cases with 106 Non-operated Cases, Matched for Age, Sex and Age of Onset of Epilepsy

	Matrices Grade		
	I & II	III	IV & V
Matched (106)	11	36	59
Operated (55)	2	16	37
Total (161)	13	52	96

$X^2 = 3.12$
d.f. = 2
$0.3 > p > 0.2$ N.S.

TABLE IV

Comparison of Performance of Operated and Non-operated Cases on Raven's Progressive Matrices

(b) Cases with onset of epilepsy from 0 - 10 years

	Matrices Grade		
	I-III	IV	V
Operated Cases (33)	5	11	17
Non-operated (58)	16	21	21
Total (91)	18	32	38

$X^2 = 2.63$
d.f. = 3
$0.3 > p > 0.2$

(c) Cases with onset of epilepsy from 11 - 20 years

	Matrices Grade	
	I-III	IV & V
Operated Cases (14)	8	6
Non-operated Cases (20)	13	13
Total 34	21	19

$X^2 = .21$ N.S.

(d) Cases with onset of epilepsy over 21 years

	Matrices Grade	
	I-III	IV & V
Operated Cases (8)	5	3
Non-operated Cases (28)	18	10
Total	23	13

$X^2 = 0$ N.S.

TABLE V

Raven's Progressive Matrices - Distribution of Scores by Age of Onset of Epilepsy in 161 Cases

(a)

Age of Onset	Matrices Grade I & II	III	IV	V	Total
0–10	3	18	32	38	91
11–20	2	19	7	6	34
21+	8	15	11	2	36
Total	13	52	50	46	161

$X^2 = 38.18$
d.f. = 6
$p < .001$

(b)

Age of Onset	Matrices Grade I & II	III	IV	V	Total
0–10	3	18	32	38	91
11+	10	34	18	8	70
Total	13	52	50	46	161

$X^2 = 29,23$
d.f. = 3
$p < .001$

(c) Deviance of 91 Cases with Onset 0–10

	Matrices Grade I & II	III	IV	V
Obtained Distribution	3	18	32	38
Expected Distribution	22.75	45.5	18.2	4.55

$X^2 = 590.9$
d.f. = 3
$p < .001$

(d) Deviance of 34 Cases with Onset 11-20

	Matrices Grade I & II	III	IV & V
Obtained Distribution	2	19	13
Expected Distribution	8.5	17	8.5

$X^2 = 5.07$
d.f. = 2
$0.1 > p > 0.05$ N.S.

(e) Deviance of 36 Cases with Onset 21+

	Matrices Grade I & II	III	IV & V
Obtained Distribution	8	15	11
Expected Distribution	9	18	9

$X^2 = 2.38$
d.f. = 2 $0.3 > p > 0.2$

interest in whether these groups differed in intellectual level when age of onset of epilepsy was taken into account, data were analysed as in Table IV(b-d). No difference between operated and matched cases emerged when cases were grouped by onset in the first decade, second decade and later onset (at age 21 or over). It therefore seemed reasonable to combine operated and matched groups. When this was done, the importance of age of onset of epilepsy in relation to general intellectual level in this sample of patients was apparent. A highly significant difference in the distribution of above average (75th %ile and above), average range (25th-74th %ile) and below average (below 25th %ile) was found, with lower intellectual levels over-represented in cases with early onset. Those with onset between ages of eleven and twenty, and onset at twenty-one or more are not deviant in their distribution of scores (Tables V, c-e).

Performance on a test of verbal function - Mill Hill Vocabulary Scale - was considered in a similar way. The total group of operated and matched patients are again found deviant, with a disproportionate number of cases at the lower end of the scale (Table VIa). On this test, however, operated and matched groups cannot be combined in considering the effect of age of onset, since these two groups are significantly different (the operated cases being significantly poorer in verbal level). Table VI(c & d) indicates that, within the group of operated cases, the pattern is the same as for performance on non-verbal reasoning (Raven's Progressive Matrices), i.e. the group with earliest onset of epilepsy (0-10) is associated with poorest performance on test. There is no such significant relationship for the non-operated/

TABLE VI

Mill Hill Vocabulary Scale (M.H.V.)

(a) Distribution of scores of 138 matched and operated cases

	M.H.V. Grade		
	I & II	III	IV & V
Obtained Distribution	14	52	72
Expected Distribution	34.5	69	34.5

$X^2 = 94.8$
d.f. = 2
$p < .001$

(b) Comparison of scores of 55 operated cases and 83 non-operated cases matched for age, age of onset and sex

	M.H.V. Grade			
	I & II	III	IV & V	
Operated Cases (55)	0	17	38	
Matched (83)	14	35	34	
Total 138	14	52	72	138

$X^2 = 16.51$
d.f. = 2
$p < .001$

(c) Distribution of scores within operated group with different age of onset

	I & II	III	IV & V
Onset 0–10 (33)	0	5	28
Onset 11+ (25)	0	12	13

Converted to 2 x 2 table
d.f. = 1
$X^2 = 7.8$
$p < .01$

(d) Distribution of scores within non-operated group with different age of onset

	M.H.V. Grade			
	I & II	III	IV & V	
Onset 0–10 (52)	7	21	24	
Onset 11–20 (19)	3	9	7	
Onset 21+ (12)	4	5	3	
Total	14	35	34	83

$X^2 = 3.65$
d.f. = 4
$p > .05$ N.S.

non-operated cases.

The third test applied routinely in the psychological assessment of cases in the Department of Surgical Neurology is the Graham Kendall Memory for Designs test. Certain errors in reproducing the 15 designs, immediately after each has been presented, were found to be indicative of the presence of organic damage and a scoring system for such errors was developed (Graham and Kendall, 1960). A cut off score of 4 minimised false positives (4%), with an area of borderline scores in which 17% of the test authors' control group fell. Table VII indicates that on this test also, the sample of patients with epilepsy under study differed from the normal population. There was less interest, however, in the deviance of the group as a whole, than in considering the effect of age of onset of epilepsy. There is once more a trend towards the association of impaired performance with earlier age of onset, but this fails to reach statistical significance. There is no difference in the performance of cases selected for surgery and non-surgical cases on this test.

The last of the four tests of cognitive function for which data were available for the retrospective study is a test of short-term verbal memory - sentence repetition. The item selected is one which appears as a subtest at XI year level in the Stanford Binet Intelligence Scale and in the Babcock Sentence Repetition Test. Table VIII indicates that failure rate on this item is not significantly different in the operated group, from that in the non-operated group, nor is there any difference attributable to age of onset of epilepsy. However, again the high proportion of poor performances in all groups must be indicated, with only one third of the cases being successful on/

TABLE VII

Graham-Kendall Memory for Designs Test (G.K.)

a) Comparison of Scores of 55 Operated Cases with 82 Non-operated cases matched for age, sex and age of onset.

	G.K. No impairment (score 0-4)	G.K. Impairment (score 4)	
Operated cases (55)	25	30	X^2 = .03
Non-operated (82)	38	44	df= 1 N.S.

b) Distribution by age of onset in 55 operated cases

	G.K. No Impairment (score 0-4)	G.K. Impairment (score 4)	
Onset 0-10	11	22	
Onset 11-20	9	5	X^2 = 4.65 df = 2 $0.1 > p > .05$ N.S.
Onset 21+	5	3	
Total	25	28	

c) Distribution of scores by age of onset in 82 non-operated cases

	G.K. No Impairment (0-4)	G.K. Impairment (5+)	
Onset 0-10 (46)	19	27	X^2 = 1.97
Onset 11-20 (22)	13	9	df = 2 $p > .05$
Onset 21+ (14)	6	8	
Total	38	44	

TABLE VIII

Short Term Verbal Memory - Sentence Repetition

a) Comparison and performance of 54 operated cases and 95 non-operated.

	Pass	Fail
Operated cases (54)	16	38
Non-operated cases (95)	40	55
Total (149)	56	93

$X^2 = 2.28$
df = 1
$P > .05$

b) Distribution of scores by age of onset in 149 cases

	Pass	Fail
onset 0-10 (97)	31	66
onset 11-20 (31)	13	18
onset 21+ (21)	12	9
Total (149)	56	93

$X^2 = 4.98$
df = 2
$P > .05$

on this item.

As with the Memory for Designs Test, the above sentence repetition task cannot be assumed to be a test of memory function, as apart from a test of general level of intellectual function in all cases. Any patient with a mental age of less than eleven would not be expected to pass this item. Graham and Kendall provide information about conversion of raw scores, to account for differences in intellectual level, for mental age as low as 6. However, in their adult standardisation sample, cases with the vocabulary equivalent of an I.Q. of less than 70 were excluded.

Since the data presented above do not demonstrate specific impairment on tests related to memory function, but rather a tendency to generally low levels of intellectual function, this point need not be pursued at present.

Thus (i) the retrospective study supported the hypothesis that the distribution of scores on tests of intellectual function in this sample of patients deviated from normal. This study was of value in indicating the need to anticipate low intellectual level in the prospective study, and efforts were made (with limited success) to supplement both tests of general intellectual function and tests of memory function. To evaluate postoperative change would be difficult if base rates were inappropriate.

(ii) The finding of a relationship between poorer performance on tests of intellectual function and early age of onset of epilepsy is of interest in confirming many studies of groups of patients with epilepsy (those undergoing neurological investigation, surgery and non-surgical groups).

2./

TABLE IX

a) General Intellectual Level and Type of Epilepsy

	Matrices Grade I&II	III	IV	V
Temporal lobe cases (63)	5	20	15	23
Non temporal lobe cases (48)	3	13	10	22
? or Non-Epilepsy cases (10)	0	3	2	5
Total (121)	8	36	27	50

$X^2 = 0.9$
df = 3 N.S.

$X^2 = 0.9$
df = 2 N.S.

TABLE IX

b) Mill Hill Vocabulary Level & Type of Epilepsy

	MHV Grade I&II	III	IV	V
Temporal lobe cases (63)	4	23	16	20
Non Temporal cases (48)	2	14	14	18
? or Non Epilepsy cases (10)	1	1	2	6
Total	7	38	32	44

$X^2 = 1.08$
df = 3 N.S.

$X^2 = 3.77$
df = 2 N.S.

2. Secondary aspects of the prospective study

This is a further description of psychological function in a number of patients in the sample of 121 who have undergone neurological investigation of epilepsy during the 4 years of the prospective study. Section 2(a) extends the analysis of the retrospective study to cover cognitive function in relation to type of epilepsy. In Section 2(b) type of epilepsy is considered in relation to results obtained on several techniques of personality and behavioural assessment. In this section also, personality and behaviour in cases selected for surgery are compared with results in those not selected for surgery.

(a) Cognitive function and type of epilepsy

It was of interest to know whether within this sample of patients with epilepsy, those with temporal lobe epilepsy could be discriminated from those with no evidence of temporal lobe involvement. Table IX (a-c) shows the results obtained for these two groups plus a third small group of cases referred for consideration of a diagnosis of epilepsy, but in whom no evidence (either clinical or EEG) of disturbance of an epileptic nature was found. No differences were found between different groups on non-verbal reasoning (Raven's Progressive Matrices) or on vocabulary. Table IX(c) indicates a significant difference. On inspection, this difference can be seen to occur largely between those obtaining borderline scores and those obtaining scores which indicated definite impairment. In addition it seemed important to exclude the non-testable cases who were most likely to reflect a generally low intellectual level, rather than a specific deficit. In Table IX(d) the data have been analysed alternatively, with only two categories. When this is done the difference between the two groups/

TABLE IX

c) Graham Kendall Memory For Designs & Type of Epilepsy

	G.K. Score Normal 0–4	Borderline 5–11	Impaired 12+	Not Testable
Temporal lobe cases (63)	35	14	4	10
Non Temporal lobe cases (48)	25	3	7	13
? or Non Epilepsy cases (10)	1	2	0	7
Total (121)	61	19	11	30

Temporal lobe vs Non Temporal lobe cases: $X^2=8.1$, $df=3$, $p < .05$

Temporal lobe vs ? or Non Epilepsy cases: $X^2=11.7$, $df=2$, $p < .01$

d) Recasting data for Table (c) (omitted untestable cases)

	Normal (0–4)	Impaired (5+)
Temporal lobe cases (53)	35	18
Non Temporal lobe cases (35)	25	10
Total	60	28

$X^2 = 0.28$
$df = 1$
$p > .05$ N.S.

groups is no longer significant. In the present study raw scores on this test have been used, instead of 'difference scores' weighted for age and intellectual level. This decision was taken because there was less interest in using this test as a means of diagnosing organic impairment. What was of importance was that a reliable instrument for the measurement of change in the performance of an individual should be used. In this area, the design reproduction task had been found acceptable.

The results obtained in this section of the study do not support the hypothesis that in patients with non temporal lobe epilepsy, performance on tests of general intellectual level was poorer, although this group did contain a larger proportion of cases unable to tackle the design reproduction task adequately for a meaningful score to be obtained.

Section 2(b)

The results obtained from the administration of two personality questionnaires are now presented.

16 Personality Factor Questionnaire (Cattell)

This provides a multidimensional measure of 16 distinct primary personality factors. Certain combinations of these yield measures of Anxiety and Introversion-Extraversion (second order factors). Cattell et al. (1970) provide personality profiles for different groups of psychiatric patients and for different physical disabilities. These profiles are derived from the mean scores of all the patients on each factor. Court (1965) administered this questionnaire to a group of 20 patients with temporal lobe epilepsy (acute admissions to a psychiatric unit).

Many/

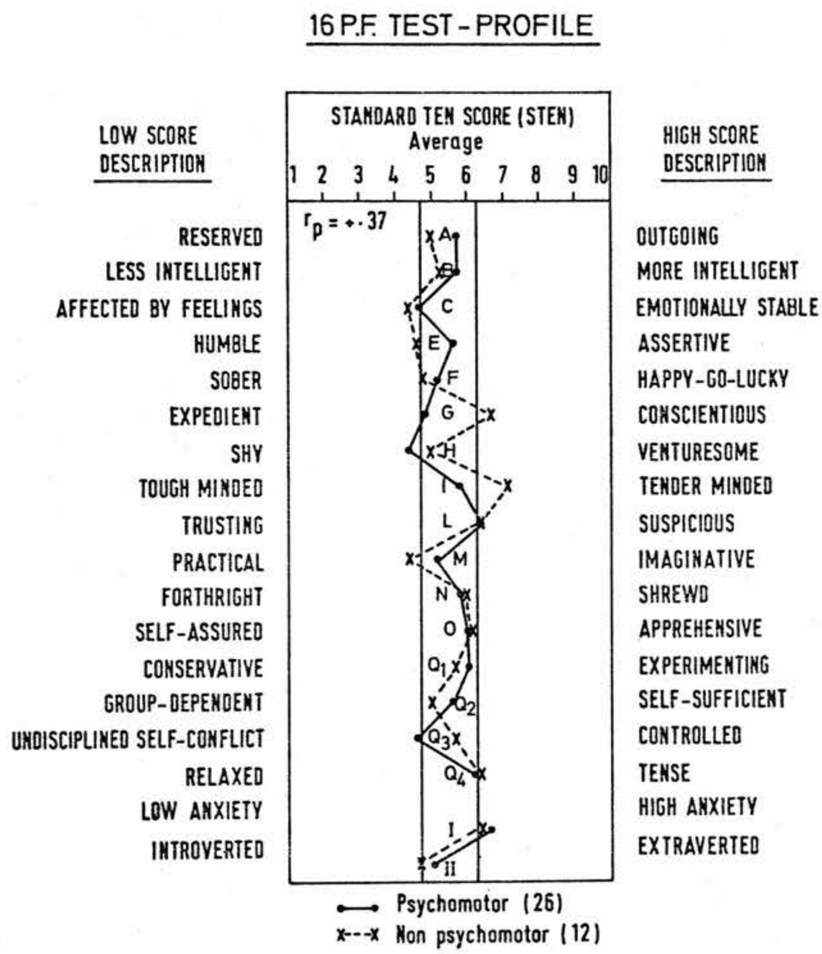

Fig.13. 16 P.F. Comparison of Group Profiles.

Many of the patients in this study were too young or too dull to cope with even the 'low literacy' version of this questionnaire. Results are available for 38 cases. Figures 1-5 provide comparisons of the personality profiles obtained by different groups and Table III provides further data on these.

First the results can be compared with the profiles provided by Cattell and Court. The profile obtained by the 38 Edinburgh cases is mildly deviant, more in keeping with the profiles of groups with physical disability (ranging from deafness to locomotor disability), and less deviant than the profiles of the groups with mental disorder (neurotic, psychotic, psychopathic and criminal groups). It is also a much less deviant profile than Court's group of temporal lobe epileptics.

Figure 13 compares the profile obtained by the 26 cases of temporal lobe epilepsy (labelled as "psychomotor" and the 12 cases of non-temporal lobe epilepsy (labelled as non-psychomotor) who were able to complete the questionnaire. Although discrepancies can be noted on individual factors, the correlation between the two profiles is positive (significant at the 0.05 level). The greatest discrepancies occur on Factor I (the non-temporal lobe group being more dependent and more sensitive) and on Factor G (the non-temporal group being more conscientious). The profile of this group of psychomotor cases is much less deviant than Court's group.

Figure 14 compares the profiles of 20 non-operated cases with the pre-operative profiles of 17 cases who underwant surgical treatment. The correlation of +0.45 between these two is significant at the 0.02 level. The greatest discrepancy occurs on Factor Q3, indicating that the operated patients are less well integrated and less

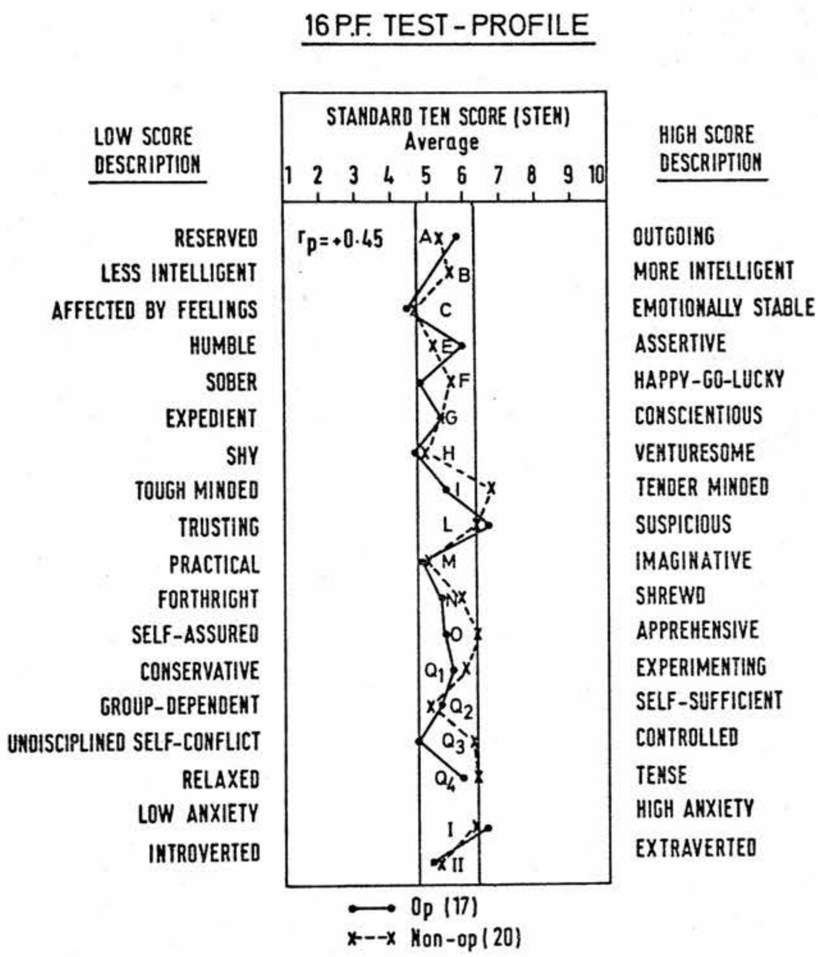

Fig.14. 16 P.F. Comparison of Group Profiles.

TABLE X : 16 Personality Factor Questionnaire
(a)

Groups		Correlation between group profiles r	p	Sten Scores (Normal Mean = 5.5) Second Order Factors Anxiety	Extraversion
Temporal lobe	(26)	+.37	p<.05	6.6	5
Non-temporal lobe	(12)			6.4	4.7
Operated	(17)	+.45	p<.02	6.5	5
Non-operated	(20)			6.3	5.1

controlled than the non-operated cases.

From Table X(a) it can be seen that on two of Cattell's second order factors (derived from combining weighted scores from certain of the 16 primary factors, none of the obtained mean sten scores is deviant. There is, however, a general trend for all groups to be marginally above the median level of anxiety and marginally more introverted than extraverted.

The Hostility and Direction of Hostility Questionnaire

Critics of the 16 Personality Factor Questionnaire claim that it does not distinguish adequately between long-standing personality traits and shorter-lived mood changes, emotional states. The Hostility and Direction of Hostility Questionnaire (HDHQ) was designed to measure this area and covers various aspects of hostility, including attitudes to others in terms of being critical of others or being self-critical, having feelings of guilt, or tending to act out, or projected hostility (related to paranoia). A measure of hostility is of particular relevance in considering the question of behaviour disorders associated with epilepsy in which acting out in the form of aggressive, impulsive behaviour and irritability are claimed as prominent features. Table X(b) gives the results obtained in 33 cases completing the questionnaire. A comparison of the epileptic group with the standardisation sample of psychiatric patients indicates that the epileptic patients' score of 23.5 was significantly higher (i.e. indicative of a higher level of hostility). It has been reported that age is a critical variable in this questionnaire and so groups of students, more comparable in age with the epileptic patients, completed the questionnaire and they obtained a significantly lower/

TABLE X (b) : Hostility and Direction of Hostility Questionnaire

	Group	No	Mean Score	SD	't' test	
From HDHQ manual	a) Normal sample	30	13	6.2		
	b) Psychiatric Patients	169	18.4	7.5	t=1.26 d.f.=253 p>.05NS	Comparing b) and d) t=3.55 d.f.=200 p<.001
	c) Students	86	17.2	6.4	t=4.53 d.f.=117 p<.001	
	d) Epilepsy Patients	33	23.5	7.7		
	e) Temporal lobe epilepsy patients	18	22.9	6.8	t=0.4 d.f.=31 p>.05NS	
	f) Non Temporal lobe epilepsy patients	15	24.1	8.9		
	g) Operated cases	15	25.4	7.2	t=1.29 d.f.=32 p>.05NS	
	h) Non Operated cases	19	22	7.9		

lower mean score. The mean score for normal groups with a wider age range as reported in the test manual is even lower (Caine et al., 1967).

No significant differences emerged on this questionnaire between temporal lobe and non temporal lobe groups or between operated and non-operated cases. Not included in the table of results, but of interest to note, is the very high mean score of 27 obtained by 2 cases in whom no epileptic phenomena were demonstrated.

In addition to other recent criticisms of this questionnaire, doubt has been cast on the validity of the method provided for obtaining an overall measure of direction of hostility, but combining weighted scores from the 5 subscales (Philip, 1973). It was decided to utilise only the total score in this part of the study (although the alternative method of calculating separate scores for Intropunitiveness and Extrapunitiveness, provided by Philip, was used in the Study of Frustration Tolerance (Appendix 1).

Adaptive Behaviour Scale

For a number of patients who were too dull or too disturbed for personality questionnaires to provide a meaningful assessment, information about behavioural disturbance was obtained through the use of a checklist. Part II of the Adaptive Behaviour Scale covers 14 areas of maladaptive behaviour. Four of these have been selected for discussion in this part of the study. These are listed in Table XI (A,B,C, M). Mean scores obtained by different groups are contained in the body of the Table. Since it is maladaptive behaviour which is scored, any score above zero is indicative of behavioural disturbance. In the original standardisation sample the proportion of cases who showed no disturbance/

TABLE XI

ADAPTIVE BEHAVIOUR SCALE (GROUP RESULTS)

Group	No.	A Violent and destructive behaviour	B Antisocial behaviour	C Rebellious behaviour	M Psychological disturbances
(1) Institutionalised subnormal epileptics	27	1.6	5.5	4.3	5.3
Institutionalised subnormal epileptics matched for age and sex with:	10	4.6	3.5	3.1	5.2
Neurological sample of patients with epilepsy	43	7.8	10.0	8.7	9.1
(2) Temporal lobe	14	5.7	8.3	9	10.6
Non Temporal lobe	21	5.8	6.6	6.6	5.4
Non Epileptic	6	14.6	16.7	11.8	14.0
(3) Operation	22	9	9.8	9.1	8.5
No operation	17	5.4	7.8	7.4	7.5
Post-op only	4	6	14.5	9.5	17.8
? further surgery					

* Difference significant at 0.05 level)
** Difference significant at 0.02 level) Using Median Split X^2 Technique
*** Difference significant at 0.01 level)

A zero score is normal.

Any score above zero indicates disturbed behaviour.

disturbance in a particular area of behaviour ranged from 20% to 70%.

Results have been obtained for 43 of the patient sample. In addition, results were obtained for a group of 27 patients with epilepsy in a local subnormality hospital. This group show significantly less violent and destructive behaviour and fewer psychological disturbances than the neurological patient sample. However, when the groups are matched for age and sex, the difference in level of violent behaviour is no longer significant but the matched institutionalised group still show fewer psychological disturbances than the neurological sample.

The psychomotor group show a higher level of psychological disturbance (which in this scale includes items such as reaction to frustration, disturbance of mood), but this is not statistically significant. The 14 psychomotor cases and the 21 non-psychomotor cases are compared with the group of 6 cases in whom no epileptic phenomena were demonstrated; the latter have a significantly higher level of violent and destructive behaviour and of psychological disturbances. None of the differences between the operated and non-operated group means is significant, although the mean of the 22 operated cases is slightly higher in area A. Four cases undergoing investigation for further surgery show higher levels of antisocial behaviour and psychological disturbances.

<u>Experimental measures</u>

The results obtained in a standardisation study on a group of student nurses are discussed in Appendix 1. However, data of relevance to this part of the study are presented in Table XII. Analysis of variance and comparisons of groups in pairs indicate few differences./

TABLE XII : Experimental Measures

a) Pursuit Rotor - Index of effect of Failure

Group	No	Mean	SD	't' test	
1. Students	22	.12	.17	t=0.47 d.f.=66 p>.05 NS	
2. Patients	46	.09	.27		
3. Temporal patients	21	.06	.21	t=0.5 d.f.=40 p>0.05 NS	
4. Non-Temporal patients	21	.10	.30		t=1.5 d.f.=23 p>.05 NS
5. Non Epilepsy patients	4	.24	.44		

Analysis of Variance between groups (1,3,4,5) d.f. among groups = 3

F Ratio = 0.58 p>.05 d.f. within groups = 64

b) Mirror Drawing - Time spent on frustrating task

Group	No	Mean	SD	't' test		
1. Students	22	10.04	3.11	t=2.05 d.f.=64 p<.05		Groups 1 and 5 t=2.87 d.f.=24 p<.01
2. Patients	44	7.68	4.9			
3. Temporal lobe patients	21	7.7	4.67	t=-0.3 d.f.=38 p>.05 NS	Groups 3 and 5 t=1.1 d.f.=23 p>.05 NS	
4. Non Temporal lobe patients	19	8.21	5.27	t=1.2 d.f.=21 p>.05 NS		
5. Non Epilepsy Patients	4	4.75	4.92			

Analysis of Variance (groups 1,3,4,5) F Ratio = 2.07 p>.05

d.f. among groups = 3 within groups = 62

TABLE XII (contd.)

c) Gibson Spiral Maze - Effect of Pressure on Performance

Group	No	Mean	SD	't' test	
1. Students	22	0.21	.11	t=0.7 d.f.=40 p>.05	groups 1 and 4 t = 1.5 d.f. = 32 p>.05 NS
2. Patients	22	0.15	.12		
3. Temporal lobe patients	10	0.16	.14	t=0.4 d.f.=20 p>.05	
4. Non Temporal lobe patients	12	0.15	.10		

Analysis of Variance between groups (1,3 and 4)
F Ratio = 1.17 d.f. among groups 2
within groups 40

p>.05 (NS)

differences. No differences were found between temporal lobe and non temporal lobe epilepsy patients. Nor did the group of patients as a whole perform differently from the control group of students on either the Pursuit Rotor task (designed to provide a measure of the effect of failure on performance) or on Gibson Spiral Maze (designed to measure the effect of stress on performance). On the Mirror Drawing task the patient group as a whole spent a significantly shorter time, with the greatest difference obtained between students and 4 patients from the small group in whom no epileptic phenomena were demonstrated.

This concludes the results relating to the secondary aspects of the prospective study. In summary, the study (i) failed to demonstrate differences between 2 groups of patients with epilepsy, one in whom there was evidence of temporal lobe involvement and the other group in whom there was no such evidence.

(ii) The study has further confirmed the whole sample of patients as deviant.

(iii) This was less marked on the personality profile obtained on the 16 P.F., but it is of interest to note that the profile was more in keeping with those of physically disabled groups than psychiatric groups.

(iv) Looking at one specific area, the patient group were found to have an abnormally high level of hostility (as assessed by questionnaire). This distinguished them not only from normal controls of a wide age range, and from a group of female students, but also from the psychiatric groups used in standardising the questionnaire.

TABLE XIII

a) Pre-operative scores on Raven's Progressive Matrices in different operative groups

Group	Mean Score	SD	't' test
1. Central (13)	24.6	6.7	
			1.5 (1 vs 2)
2. Amygdalotomy (14)	30	11.8	1.9 (1 vs 3 Left)
3. Temporal Lobectomy			2.2 $p < .05$ (1 vs 3 Right)
Left (8)	33.6	14.6	
Right (7)	32.7	9.2	0.14 (Left vs Right)

(v) Use of a behaviour checklist showed the patient group to be more disturbed than a sample of mentally subnormal institutionalised patients with epilepsy (matched for age and sex).

(vi) On one of 3 standard situations designed to provide a measure of frustration tolerance patients were significantly less persistent than a group of students.

(vii) Within the patient group the indications over a number of measures used are that the most deviant cases are a small number referred with a provisional diagnosis of epilepsy, in whom no epileptic phenomena were demonstrated.

3. Pre- and post-operative assessment of cognitive function

Whereas in the foregoing sections, interest was in comparisons between groups, differentiated on some criterion, the emphasis now shifts to change over time within the individual. In this, the main part of the study, individual changes are analysed according to type of neurosurgical procedure (and whether the procedure was unilateral or bilateral). In addition, length of follow-up has been taken into account. When all these variables are considered, the numbers in any group are inevitably small (from 13 to 1). Data are often presented in the form of change scores based on differences between pre- and post-operative performance, but methods based on group differences are also utilised.

Table XIII gives the results for different groups on a test of general intellectual function (Raven's Progressive Matrices). First, (Table XIIIa) it is important to note that the pre-operative level of the main operative groups is broadly comparable. The central group, however, tend to have a lower level than other groups, and significantly/

significantly lower than the right temporal lobectomy group.

Table XIII(b) gives the postoperative change in performance for these groups. A comparison of the relatively small change in mean scores, with large standard deviations of most groups, is indicative of the variance within each operative group which tends to rule out the possibility of demonstrating significant changes dependent on type of operation. This is confirmed by one way analysis of variance; 't' tests between pairs of groups were also carried out. The only statistically significant difference to emerge is indicated - while in the short-term follow-up, cases undergoing bilateral amygdalotomy showed a decline, in the long term there is an improvement to above pre-operative level. The difference between short and long term follow-up is statistically significant.

Table XIII(b) also analyses the results in terms of the number of individuals in each group whose performance improved, showed zero change, or declined. There are no significant differences, using this method, between the operative groups, nor between unilateral/bilateral procedures, nor between short and long term follow-up.

This can be tested by the Fisher test for small samples (where $N < 30$). Nevertheless, a slightly higher proportion of bilateral central cases do continue to show decline at long-term follow-up. On this test, there is adequate standardisation data to consider how many of the individual changes in score were greater than expected on the basis of the known test-retest reliability.

Table XIII(c) gives this information, based on Payne and Jones' formula (vide Methods Section). Thus, no case showed an improvement greater than expected. A total of 7 cases showed greater than expected/

TABLE XIII (contd.)

b) Post-operative changes in scores on Raven's Progressive Matrices for 3 main operative groups

	Group	No	No +	No 0	No -	Post op. change Short term Mean	Short term SD	Long term Mean	Long term SD	't'	Level of significance
1.	Central-Unilateral	11	6	-	5	0.8	6				
2.		3	2	-	1			0.3	3		
3.	Bilateral	4	2	-	2	-0.7	7.4				
4.		6	3	-	3			-3.3	9.5		
5.	Amygdalotomy Unilateral	1	1	-	-	3	0				
6.		3	3	-	-			5	4		
7.	Bilateral	7	3	-	4	-2.3	5.9			2.2	$p<.05$
8.		10	6	2	2			3	4		
	Temporal Lobectomy										
9.	Left	7	4	1	2	1.8	6.2				
10.		7	4	1	2			2.4	4		
11.	Right	6	4	-	2	1.8	7.2				
12.		2	1	1	-			6.5	9.1		

Note:- Only statistically significant values of 't' are included.
Analysis of Variance of difference scores.

1) All groups d.f. among groups = 9 F Ratio = 0.9
d.f. within groups = 54 $p>0.05$ NS
2) Long term results for groups 4,7 and 10
d.f. among groups = 2 F Ratio = 2.36
d.f. within groups = 20 $p>0.05$ NS

TABLE XIII (contd.)

c) Raven's Progressive Matrices

Analysis of individual changes, based on test-retest reliability data

	Significant Improvement		Significant Deterioration	
	Short term	Long term	Short term	Long term
1. Central				
Unilateral	0	0	1	0
Bilateral	0	0	2	1
2. Amygdalotomy				
Unilateral	0	0	0	0
Bilateral	0	0	2	0
3. Temporal Lobectomy				
Left	0	0	1	0
Right	0	0	1	0
Total	0	0	7	1

expected decline in performance in the short term, while only one case showed significant long term deterioration. This case must be regarded as an atypical central case in that the procedure was carried out, at an early stage in the project, by a different neurosurgeon and was a one-stage bilateral procedure, while in the other patients in whom bilateral central lesions were made there was an interval of weeks or months before the contralateral lesion was made.

In all, therefore, there were 8 significant changes out of a maximum possible of 67. This is interpreted as confirming the other analyses of these data that there is relatively little change in the group as a whole. This method was particularly instructive in demonstrating that apparent improvement in score was accounted for in terms of practice effect, while a similar change in score in a downward direction was more meaningful.

Analysis of change in verbal function (Mill Hill Vocabulary Scale) was carried out in a similar fashion. The preliminary comparison of pre-operative levels is not tabulated for this test, as no significant differences emerged between the groups. Table XIV(a) gives the change scores obtained on this test. Again, relatively small mean change scores are accompanied by large standard deviations. Both overall analysis of variance and comparisons between pairs of groups fail to yield any statistically significant differences. In Table XIV(b) the significance of individual changes is considered. This reveals a larger number of changes than on non-verbal reasoning (Raven's Matrices). A total of 13 significant changes out of a maximum possible of 64 are identified. This, in turn, is a significantly greater number than the 5% expected by change ($X^2 = 6.062$). The/

<u>TABLE XIV</u> : Pre and Post Operative Changes in Scores on Mill Hill Vocabulary Scale for 3 Main Operative Groups

a)

Group	No	No +	No 0	No -	Change in score Short term Mean	Short term SD	Long term Mean	Long term SD	't'	Level of significance
1. Central - Unilateral	11	4	2	5	-1.1	3.5				
	3	1	-	2			-1	3		
Bilateral	4	1	-	3	-3.2	3.5				
	6	3	-	3			-7.5	16.8		
2. Amygdalotomy - Unilateral	1	1	-	-	4	0				
	3	1	2	-			1.6	2.8		
Bilateral	7	3	-	4	-2.4	5.4				
	9	4	-	5			0.2	6.9		
3. Temporal Lobectomy - Left	7	2	-	5	-2.8	6.9				
	6	2	-	4			-3	11.8		
Right	4	2	-	2	1.2	4.8				
	2	1	1	-			6	8.5		

Analysis of Variance between Groups

F Ratio = 0.58
$p > .05$ NS

d.f. between groups = 9
d.f. among groups = 50

TABLE XIV (contd.)

b) Mill Hill Vocabulary Scale

Analysis of individual changes, based on test-retest reliability data

	Significant Improvement		Significant Deterioration	
	Short term	Long term	Short term	Long term
1. Central				
Unilateral	0	0	2	0
Bilateral	0	0	0	2
2. Amygdalotomy				
Unilateral	0	0	0	0
Bilateral	0	1	1	0
3. Temporal Lobectomy				
Left	1	1	2	2
Right	0	1	0	0
Total	1	3	5	4

The overall trend is again downward in that 9 of the 13 changes indicate decline. Of these, 5 are short-term and 4 long-term results. Two cases in the bilateral central group and two left temporal lobectomy patients showed significant long-term decline. No central cases improved significantly postoperatively. It is slightly surprising to find a significant improvement on a vocabulary test both immediately and maintained in the long term, in a case of left temporal lobectomy. This case functioned well above the average of the group. A high postoperative verbal level is confirmed by this patient's academic success in taking a degree in Law. There was no evidence to indicate right cerebral dominance, although it is of interest to note in this case a long-term slight (not significant) decline in performance on non-verbal tests - non-verbal reasoning and design reproduction.

All three patients in whom improvement was noted showed a marked reduction in seizure frequency.

Of course, this method of analysis, using raw scores, does not take account of change with age. This does not apply in the short term, but must be considered in any evaluation of long term change. Since no cases occurred within the age range where deterioration is expected, this could be ignored in interpreting the group showing decline. However, all three cases in whom improvement was noted fell within an age range (16-25) where improvement should occur. This effect can be checked simply, by using age-based grades instead of raw scores. All three cases showed an upward change of grade and hence long-term postoperative improvement was greater than expected from maturation alone.

Finally/

Finally, to investigate whether there was a significant postoperative decline following neurosurgical intervention, all preoperative raw scores were compared with all postoperative scores, taking short and long term results separately. The difference in mean in both cases was 2 score points and this was not significant for the groups of scores compared.

Table XV gives the difference between pre- and post-operative performance on the Memory for Designs Test (Graham Kendall). There is greater overall variance on this test, but again the F ratio fails to reach statistical significance. It is important to note that on this test '+' represents a poorer performance (i.e. increase in error score). The only group in whom there is an improvement is the bilateral amygdalotomy group, in the long term. This is significantly different from the deterioration occurring immediately following this procedure (bilateral amygdalotomy, short-term). Incidentally, this difference is also demonstrated when the results are analysed by contrasting the number of cases showing improvement, zero change and decline (using Fisher test).

Several of the mean changes on this test are quite substantial (e.g. bilateral central cases, both short and long term), but as with the two tests already discussed, there is great variation within the groups (demonstrated both by large standard deviations and by the numbers improving and declining). Variation in the direction of change prevents discrimination being made between groups undergoing different neurosurgical procedures.

The last of the four tests routinely administered is a test of short-term memory for verbal material (Sentence Repetition). This is not/

TABLE XV : Post-operative changes in Scores on Graham

Kendall Memory for Designs Test for 3 Main Operative Groups

Group	No.of Cases	No.of cases +	0	-	Post op. change Short term Mean	SD	Long term Mean	SD	't' test
Central									
1. Unilateral	12	6	1	5	0.3	3.7			
2.	2	1	1	-			1.5	3.5	
3. Bilateral	4	3	-	1	8.5	13.3			
4.	5	3	-	2			5.2	13.8	
Amygdalotomy									
5. Unilateral	1	-	-	1	-1	0			
6.	3	2	-	1			1.6	3.2	$t = 3.3$
7. Bilateral	5	4	-	1	2.8	3.3			
8.	8	1	1	6			-2.7	2.9	$p < .01$
Temporal Lobectomy									
9. Left	7	3	3	1	2.8	5.4			
10.	7	3	2	2			1.3	4.7	
11. Right	5	2	1	2	0.6	5.3			
12.	3	2	1	-			2.3	2.1	

Note:- 1) An increased score on this test represents a poorer performance.
2) Only statistically significant values of 't' are indicated.

Analysis of Variance a) Short term results (d.f. between groups = 4, d.f. within groups = 28) F Ratio = 1.68, $p>0.05$ NS

b) Long term results (d.f. between groups = 2, d.f. within groups = 18) F Ratio = 1.86, $p>0.05$ NS

TABLE XVI : Pre and Post Operative Change in Performance on Short-term Verbal Memory (Sentence Repetition) for 3 Main Operative Groups.

a)

Group	No	pre ✓	pre x	Pass ✓ Fail x post Short term ✓	post Short term x	post Long term ✓	post Long term x	Fisher test for small groups
1. Central								
Unilateral	10	4	6	3	7	-	-	
	3	3	0	-	-	2	1	
Bilateral	5	5	0	1	4	-	-	
	5	5	0	-	-	2	3	
2. Amygdalotomy								
Unilateral	1	1	0	1	0	-	-	
	3	2	1	-	-	2	1	
Bilateral	7	4	3	3	4	-	-	p<.05
	9	3	6	-	-	3	6	
3. Temporal Lobectomy								
Left	7	3	4	3	4	-	-	
	7	2	5	-	-	2	5	
Right	5	3	2	5	0	-	-	
	2	1	1	-	-	1	1	

not amenable to quantitative evaluation, but analysis is made in terms of a pass/fail dichotomy. The results are contained in Table XVI. Applying the Fisher test for small groups to the differences between pre- and post-operative performance and between different operative groups indicates that there was a significant decline immediately following bilateral central lesions. In addition, the immediate post-operative performance in this group (5 cases) was significantly worse than that of the 5 cases who underwent right temporal lobectomy, while pre-operative performance was better in the central group.

Details of tests used to supplement the above, for reasons given in the section on Methods, are given in Tables XVII-XXII. Results tend to be available on even fewer cases, but will be commented on briefly.

A similar analysis to that in earlier tests was carried out on results obtained on Williams Delayed Recall test (Table XVII). The pattern is similar to that noted previously. Overall variance is not at a statistically significant level. A positive mean score represents a decline in performance (increase in number of errors). Most groups showed at least slight decline. Five bilateral amygdalotomy cases again showed short-term decline, but long-term improvement over pre-operative level. On this test, however, the difference fails to reach statistical significance. The largest mean changes on this test were shown by left temporal lobectomy cases in the short term follow-up and in the long term by 2 bilateral central cases and one right temporal lobectomy.

On Williams Verbal Learning Test pre- and post-operative scores are given (Table XVIII). Again, an increase in score represents a poorer/

TABLE XVII : Post Operative Changes as Score on Williams' Delayed Recall Test for 3 Main Operative Groups

Group	No	Mean Pre-Op. Score	Change in Score Short term Mean	SD	Long term Mean	SD	't' test
1. Central Unilateral	4	10	-0.2	3.4			
2.	2	7			+3	1.4	
3. Bilateral	3	6	+5	4.5			
4.	2	7			+8.5	2.1	
Amygdalotomy							
5. Unilateral	1	2	0	0			
6. Bilateral	5	14.6	+11.8	19.3			
7.	5	16.8			-4.6	11.6	
Temporal							
8. lobectomy Left	3	6.6	+21.3	22.8			
9.	3	6.6			+1.3	4	
10. Right	3	4.3	+2.3	9.8			
11.	1	11			23	0	

Analysis of Variance F Ratio short term results (groups 1,3, 6,8 and 10)

$= 0.9 \quad p > 0.05$

F Ratio long term results (groups 4,7, and 9)

$= 1.8 \quad p > 0.05$

Note: Increase in score on this test represents <u>poorer</u> performance.

TABLE XVIII : Williams Verbal Learning Test

Group	No	pre-op.	Mean Score post-op. Short term	Long term
Central -				
Unilateral	3	4.3	2	-
	2	9	-	11
Bilateral	2	9	16	-
	1	27	-	37
Amygdalotomy				
Unilateral	1	0	0	-
	2	26	13.5	-
Bilateral	5	17.6	-	17.2
Temporal				
Lobectomy Left	3	11.7	24.7	
	2	15.5	-	20.5
Right	2	0	1.5	-

TABLE XIX : Supplementary Testing of Intellectual Level

a) WAIS

Operation	No.	Verbal I.Q.			Performance I.Q.			Full Scale I.Q.		
		pre	post ST*	post LT	pre	post ST	post LT	pre	post ST	post LT
Central Unilateral	1	75	84	-	80	87	-	75	83	-
	1	94	-	94	79	-	81	86	-	88
Amygdalotomy Bilateral	1	104	107	-	106	109	-	104	107	-
Temporal Lobectomy Right	1	124	124	-	93	93	-	111	111	-
Exploration only	1	82	88	-	78	87	-	78	87	-

* ST = Short term
LT = Long term

poorer performance. As expected on this test, cases undergoing left temporal lobectomy show postoperative impairment, persisting into longer term follow-up. However, the 3 bilateral central cases to whom this test was administered also showed a postoperative decline, two retested within the first 3 months only and the third more than 3 months postoperatively. Two cases of bilateral amygdalotomy tested within 3 months of operation showed improvement on this test, but the long-term postoperative follow-up on the slightly larger number of 5 cases of bilateral amygdalotomy showed no difference from their pre-operative score. This is of considerable interest in view of the implication of the role of the amygdala in relation to temporal lobe structures, in learning.

Table XIX gives the results for a few cases on supplementary tests of intellectual level. Complete pre- and post-operative results on the Wechsler Adult Intelligence Scale were obtained in only 6 cases. These are given in Table XIX(a). There are no significant changes, and the short-term increases are likely to be due to practice effects. It is possible that some selection factor operated here, in that only the more co-operative patients, in whom the routine tests had established the possibility of applying the more extensive WAIS test, were tested.

The Stanford Binet Intelligence Scale (3rd Revision Form L-M) tended to be applied to cases at the other end of the scale, i.e. those on whom it was difficult to obtain a baseline of performance using Raven's Matrices and Mill Hill Vocabulary Scale. While the retrospective study led to the anticipation of quite a sizeable category, it transpired that many cases were too dull for the Stanford Binet/

TABLE XIX (contd.)

b) Standard Binet Intelligence Scale

Operation	No	I.Q. pre	I.Q. post Short term	I.Q. post Long term
Central	1	59	65	-
Amygdalotomy	2	49	53	-
	2	40	-	42.5
Amygdalectomy	1	33	-	31
Insertion of shunt	1	49	61	51

Binet to be useful. There were 7 such cases in the operative group whose mental age had to be regarded as below the minimum 2 year level of the test (with I.Q. equivalent <30, which is a concept of little value at this level of functioning). Intelligence Quotients obtained on the Stanford Binet test for a further 7 cases are given in Table XIX(b). Interpretation of significance of change is difficult at the level represented here. However, it is of interest to note that in both cases showing greatest improvement (one central, one shunt insertion), this was accompanied by marked reduction in both seizure frequency and in behavioural disturbance.

The Porteus Maze Test is claimed by its author (Porteus, 1955) to measure foresight and planning capacity and to be much more sensitive than the Wechsler-Bellevue Scale to changes following a range of psychosurgical procedures, including transorbital lobotomy and thalamotomy. Porteus reported such changes to be long lasting. A Test Quotient (T.Q.) is derived for the patient, based on the number of mazes correctly solved and the number of trials taken to do so. In addition, Porteus provides a method of scoring qualitative errors (cutting corners in drawing the maze, making errors at certain stages in the design and so on). This 'Q' score was found to discriminate delinquents from non-delinquents, the higher score of the former being interpreted as indicative of impulsivity. Table XIX(c) gives results for the few cases who completed this test pre- and postoperatively. As with the Mill Hill Vocabulary Scale and Williams Memory Scale subtests, alternative forms are available so that test results are uncontaminated by practice effects. In general, test age shows a decline postoperatively. Porteus reported a drop of 30 points/

TABLE XIX (contd.)

c) Porteous Maze Test

Operation	No	Test Quotient Pre	Test Quotient Post Short term	Test Quotient Post Long term	t	'Q' Score Pre	'Q' Score Post Short term	'Q' Score Post Long term
1. Central Unilateral	3	109	-	72	2.36NS	-	-	-
	2	-	-	-		29.5	-	56
2. Amygdalotomy								
Unilateral	1	74	94	-		45	24	-
Bilateral	1	129	118	-		3	14	-
3. Temporal Lobectomy								
Left	1	106	102	-		40	40	-
	2	127.5	-	105.5		53	-	43.5

points in T.Q. following thalamotomy, which is comparable to the drop obtained by the 3 central cases tested. The drop in the one case of bilateral amygdalotomy is not so great. The drop listed for 2 left temporal lobectomy cases is wholly attributable to a drop of 46 points in one case, in whom right cerebral dominance was indicated pre-operatively by sodium amytal test, and whose postoperative performance on other non-verbal tests of a perceptual nature, including Raven's Progressive Matrices and Graham Kendall Memory for Designs showed a comparable decline. The central cases showed no such change on non-verbal reasoning (Raven's Matrices) but a decline on Memory for Designs. As regards 'Q' score, these tend to be high (Porteus quotes a delinquent group mean of 40, and a non-delinquent group mean of 22). Of greater interest, in connection with postoperative changes in personality assessment discussed in the next section, is the finding that in the central cases 'Q' scores showed a marked increase, while right temporal lobectomy and amygdalotomy obtained smaller 'Q' scores postoperatively.

The data in Table XX(a) is presented very tentatively, in view of the small numbers and the technique itself, being a non-standardised modification of a test described by Brenda Milner (1968). She was able to demonstrate impairment in the selection of photographs of faces seen 1½ minutes earlier following right temporal lobectomy. The test was introduced in the present study at a late stage, following reports in 3 cases of bilateral amygdalotomy of disturbances in the recognition of people. In one case this was part of a transient postoperative gross amnestic syndrome in which the patient greeted as familiar a number of people whom he had not met before and failed to/

TABLE XX : Non Standardised Tests of Cognitive Function

a) Photograph Recognition

Group	No	Mean Score Pre	Post
1. Central	3	8.7	8.7
2. Amygdalotomy	3	8.3	6
3. Temporal Lobectomy	2	11	9

b) Word Fluency

Group	No	Mean Score Pre	Post	't'	p
1. Central	5	20.4	26.4	1.0	>0.05
2. Amygdalotomy	2	20.5	28	[0.5	>0.05]
3. Temporal Lobectomy	3	31.6	28.7	[0.3	>0.05]

to identify close relatives. Nine months postoperatively this patient's performance on the test was perfect. In the other 2 cases recognition of people was reported as a more specific disorder, but both these patients were duller, less able to verbalise and less reliable. Milner has discussed the type of deficit occurring in relation to prosopagnosia, demonstrated following parietal lesions. A method of investigating this agnosia for facial configuration was described by Gloning and Quatember (1966). One of the tests described has been applied to a few cases in the present study. One case of right temporal lobectomy, in whom WAIS scores pre- and postoperatively were identical, made more errors on photograph recognition and was slower and less accurate on schematic face matching (test for prosopagnosia). Of the 8 cases to whom the photograph recognition task has been given, the 3 central cases showed no change, while 3 bilateral amygdalotomy cases and 2 temporal lobectomies showed a drop in postoperative score.

Table XX(b) is also presented tentatively. This Word Fluency task was an item from X year level on the Stanford Binet scale. It is recognised that requiring the patient only to say as many words as possible in one minute, rather than, for example, naming as many fruits beginning with the letter 'p', is a very different task conceptually. However, on the few cases tested the central and amygdalotomy cases became more fluent while the two temporal lobectomies were less so.

Table XXI gives some data on simple reaction time in a control group of mentally subnormal institutionalised patients with epilepsy. Change in the mean for each individual on a series of trials on two occasions/

TABLE XXI : Reaction Time (RT) (Gogarburn Patients) N = 35

	Group I			Group II			Group III			Group IV		
	RT_1	RT_2	Diff.	RT_1	RT_2	Diff.	RT_1	RT_2	Diff.	RT_1	RT_2	Diff.
Meter Reading	3	2.9	-0.1	5.0	4.5	-0.5	7.5	7.0	-0.5	8.2	6.9	-1.3
	4.6	3.7	-0.9	3.0	2.4	-0.6	7.1	6.3	-0.8	6.7	5.3	-1.4
	4.4	3.8	-0.6	3.7	3.1	-0.6	3.0	2.2	-0.8	5.5	4.1	-1,4
	3	2.8	-0.2	2.0	1.7	-0.3	2.6	4.0	+1.4	1.9	2.0	+0.1
	2.2	2.6	+0.4	3.0	3.2	+0.2	2.7	2.3	-0.4	3.9	2.9	-1.0
	2.7	2.1	-0.6	4.7	5.3	+0.6	3.6	5.5	+1.9	4.5	3.9	-0.6
	5.9	8.0	+2.1	2.1	2.0	-0.1	3.1	3.5	+0.4	4.4	5.1	+0.7
	5.5	4.2	-1.3	3.7	4.2	+0.5	3.0	2.5	-0.5			
	3.6	3.3	-0.3				1.6	3.0	+1.4			
	2.5	2.1	-0.4				3.7	3.9	+0.2			
No.	10			8			10			7		
Mean	3.7	3.5	-0.2	3.4	3.3	- .1	3.79	4.1	+0.3	5.0	4.3	-0.7
Time in Secs	0.6	0.6	-0.2	0.53	0.5		0.63	0.67		0.9	0.75	

a) Analysis of Variance between Groups I - IV   Degrees of Freedom among sets = 3
Degrees of Freedom within sets = 30

F Ratio = 2.11 $p > 0.5$ (N.S.)

b) Test-Re Test Correlation for whole sample

$r_{RT_1 RT_2} = 0.88$ (Pearson product Moment correlation for N = 35)

TABLE XXII : Post-operative Changes in Reaction Time

Group	Significantly Quicker		Significantly Slower		Insignificant Change	
	Short term	Long term	Short term	Long term	Short term	Long term
a) Central (9)	1	2	2	1	6	6
b) Amygdalotomy (5)	3	1	1	0	1	4
c) Temporal Lobectomy (7)	1	1	3	1	3	5

occasions, six months apart, was under consideration. Since there was no overall difference when cases were grouped according to certain changes in drug regime, all groups were combined to obtain a measure of test-retest reliability. The method appeared reliable (r = 0.88). This study was undertaken partly because there had been some doubts about the reliability of reaction time in mentally subnormal patients and patients with epilepsy, and hence it was necessary to obtain some measure of this prior to using the task to investigate pre- and post-operative differences. In considering the operated cases, repeated readings for each individual, with each hand, are treated as forming two samples and compared using a 't' test. Detailed results are given in Table XXXIX (Appendix 4). A summary of significant changes is given in Table XXII. The majority showed no significant change and where change did occur it tended to be within the first 3 months after operation, not in the long term. A higher proportion of amygdalotomy patients showed short-term improvement (i.e. shorter reaction time), while a higher proportion of temporal lobectomy cases were slower. This tended to be associated, as it also was in the central cases, with weakness in the hand contralateral to the site of surgery. Significant postoperative changes were not associated with change in seizure control. Only results for simple reaction time are indicated.

This concludes the presentation of results pertaining to pre- and post-operative cognitive function, and the following points must be made:-

(1) The diversity of techniques themselves and the very limited number/

number of cases in which many have been utilised, makes it difficult to evaluate this part of the study.

(2) In considering postoperative change in cognitive function, an overall trend of transient postoperative decline has been found. This was apparent in raw scores where alternate forms of the test were used and otherwise when practice effect was taken into account on a number of tests in which there were postoperative increases in score.

(3) There was a marked reversal in the longer term of such transient decline in performance following bilateral amygdalotomy, as assessed on non-verbal reasoning and memory for designs. Nor did this procedure produce any case of long-term decline in vocabulary level. Bilateral lesions in central brain areas tended to be followed by greater decline on most tests. These occurred immediately postoperatively and tended to persist in the longer term. This applied whether analysis was based on mean change score, on the number of individual cases showing significant change or in the proportion showing improvement/decline. As expected, verbal function and memory (for both verbal and non-verbal material) was adversely affected by left temporal lobectomy. On no test was this effect sufficiently specific to this group, in either short or long term postoperative follow-up, to distinguish this group from other operative groups. This results from the small numbers within each group and wide variation of individual changes in performance within each group. It was rarely possible with these numbers to discriminate statistically between groups based on type of neurosurgical procedure, whether unilateral or bilateral, and between follow-up within/

within 3 months of operation or more than 3 months postoperatively.

(4) It was not anticipated that it would be possible to evaluate the assessment techniques themselves, nor to establish the degree of overlap between tests, with the small numbers and diversity within the sample. However, it does seem important to indicate the ease of administration to a rather dull and not very co-operative group of patients, of Raven's Progressive Matrices and Mill Hill Vocabulary Scale as measures of general intellectual level, in contrast with the more extensive Wechsler Adult Intelligence Scale. In addition, while results for the latter were available for only a few cases in this study, it appeared less sensitive to change than the former two tests. Where supplementary tests were used these did sometimes confirm previous reports, with indications for example of the Porteus Maze being sensitive to changes following central brain lesions, and specific aspects of memory function (but not a verbal learning task) showing changes following amygdalotomy. A study of simple reaction time indicated a pattern of changes different from other test results with implications for the role of the amygdala in attentional processes, aand not confirming a general slowing down following central lesions, accompanying the drop in scores on tests of cognitive function. Where tests were supplemented with the aim of monitoring performance in very dull patients, this was relatively unsuccessful. Nevertheless, it is still maintained that some check on pre- and post-operative cognitive function in such patients is important, though difficult to achieve.

4.7

4. Pre- and post-operative assessment of personality and behaviour

(1) Personality questionnaires

For both questionnaires for which results are reported (16 P.F. and HDHQ) pre- and post-operative group results are compared. It was not possible to consider short and long term follow-up separately for these. Length of follow-up was comparable in all three main groups (6-7 months). Age is also comparable in all three groups (with mean of 30.3 years).

Figures 15-17 give pre- and post-operative profiles on the Sixteen Personality Factor Questionnaire, and further information is contained in Table XXIII(a). The major neurosurgical procedure, unilateral temporal lobectomy, produces least change in pattern of responses to this questionnaire (with the correlation between pre- and post-operative profiles being a significant one (+0.45). The two groups undergoing the other procedures both show negatively correlated pre- and post-operative profiles, although in neither case does this reach a significant level. In the 8 cases in whom central stereotactic lesions were made, the direction of change is in keeping with clinical observation indicating postoperative disinhibition. This group shows significantly increased scores on Factors F and H, and slight increases on Factors C, E, Q_1 and Q_2. These changes are reflected in two second-order factors, with postoperative decrease in anxiety and increase in extraversion from low average to a high score (Sten 4.7 - Sten 7).

While comparison of the group profiles for 5 amygdalotomy cases yielded a negative correlation slightly greater in magnitude, individual factor changes were not significant for this group, nor were there/

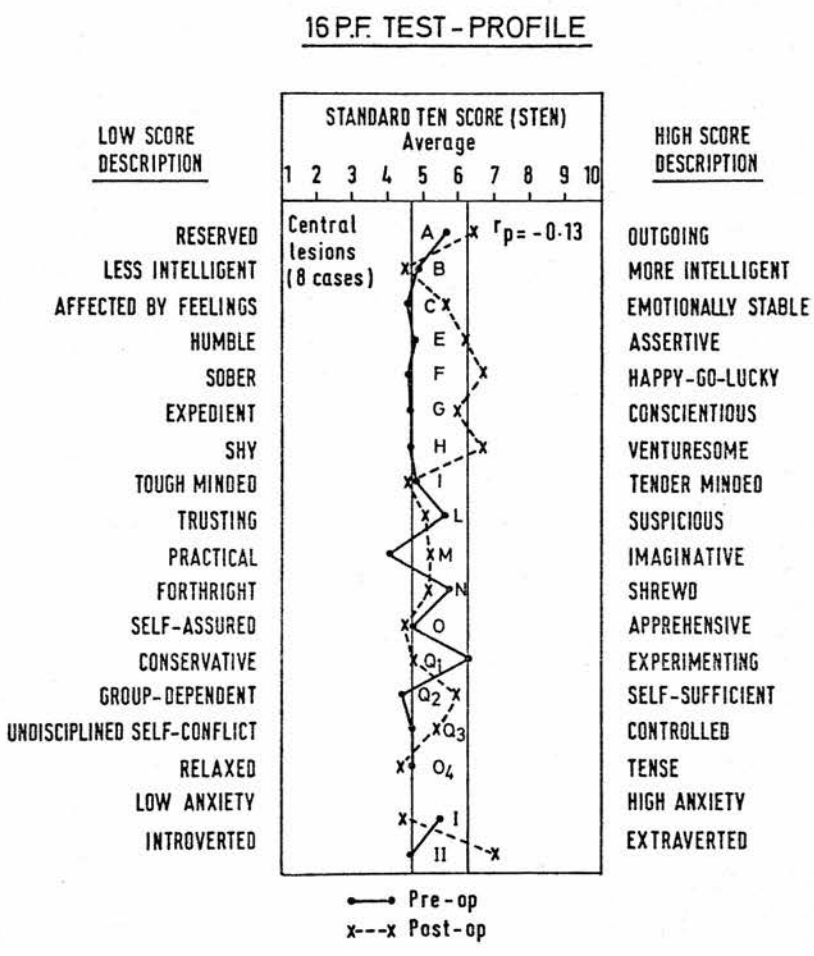

Fig.15. 16P.F. Comparison of Group Profiles.

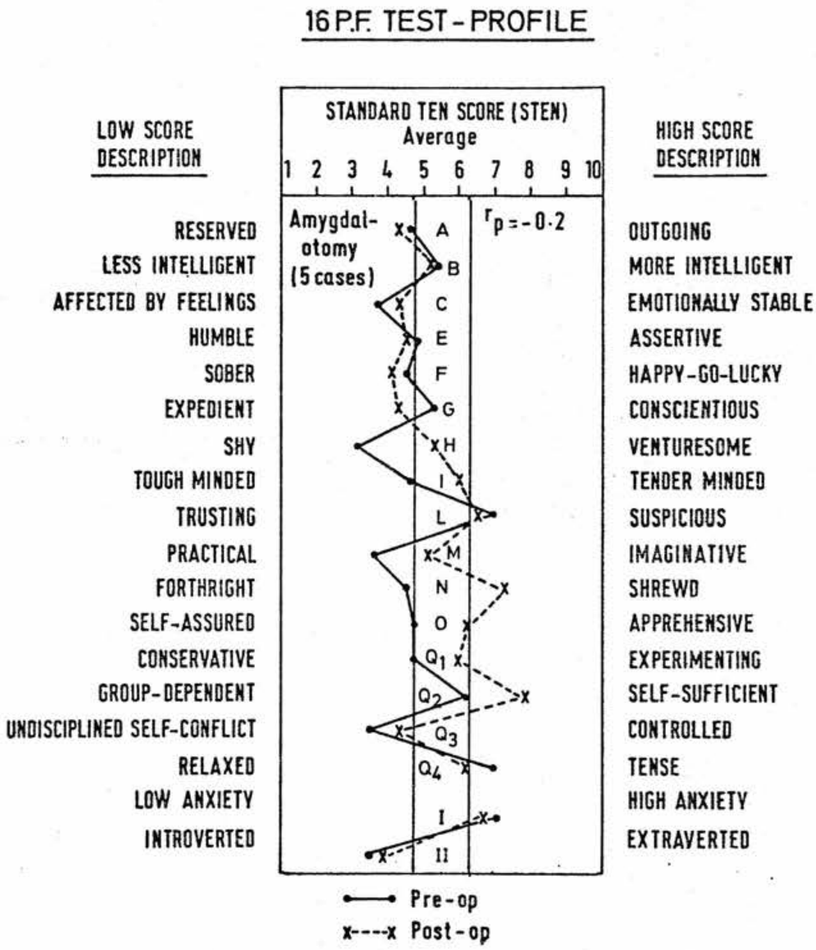

Fig.16. 16 P.F. Comparison of Group Profiles.

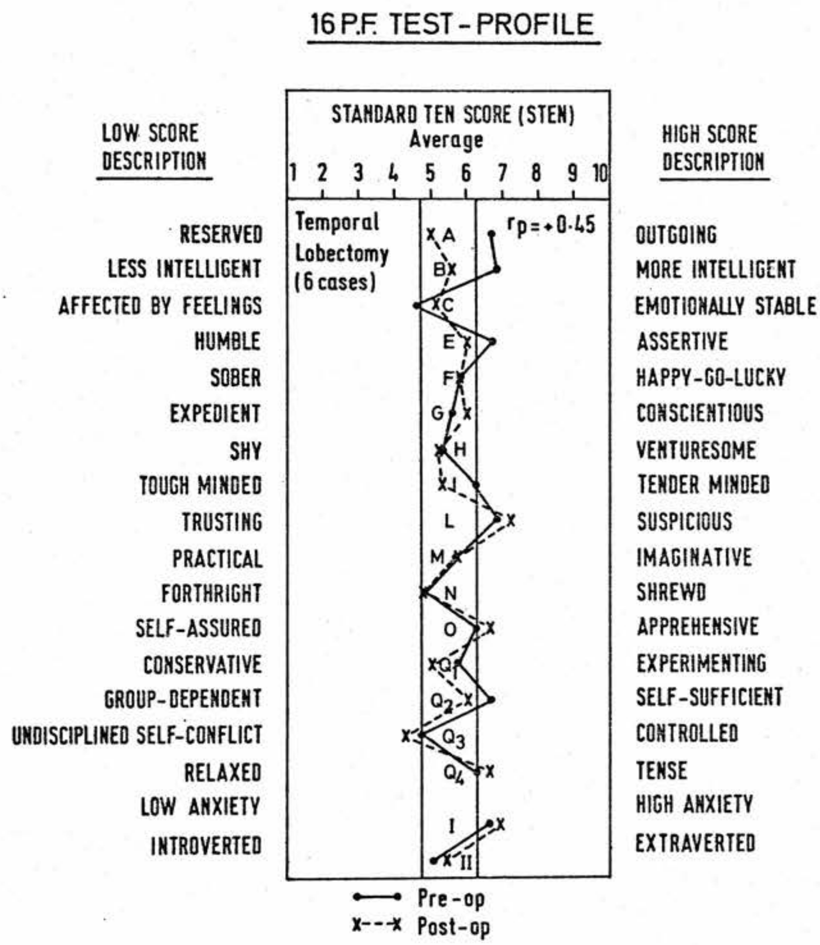

Fig.17. 16 P.F. Comparison of Group Profiles.

TABLE XXIII (a) : 16 Personality Factor Questionnaire

Groups		Correlation between Group profiles r	p	Sten Scores (Normal Mean = 5.5) Second Order Factors Anxiety	Extraversion
1. Central	pre-op	-0.13	p>.05	5.5	4.7
(8)	post-op			4.4	7.0
2. Amygdalotomy (5)	pre-op	-0.2	p>.05	7.0	3.3
	post-op			6.8	3.7
3. Temporal Lobectomy (6)	pre-op	+0.45	p .01	6.6	5
	post-op			6.9	5.4

TABLE XXIII(b): Hostility and Direction of Hostility Questionnaire

Pre and Post Operative Scores for 3 Main Operative Groups

Group No	Pre-op. Score Mean	Pre-op. Score SD	Post-op. Score Mean	Post-op. Score SD	't'	Diff. Score Mean	Analysis of Variance of pre/post op.change
Central (5)	24.2	8.4	.17	4.2	1.71 NS	-7.2	F Ratio = 2.7
Amygdalotomy (5)	26.8	8.8	26	4.9	0.17 NS	-0.8	d.f.between groups=1 within groups =8
Temporal Lobectomy (5)	24.2	4.7	20.4	9	0.83 NS	-3.8	p > .05

Group No	Pre-op. Score Mean	Pre-op. Score SD	't'
Central (5)	24.2	8.4	
			0.4 NS
Amygdalotomy (5)	26.8	8.8	
			0.5 NS
Temporal Lobectomy (5)	24.2	4.7	

there changes in second-order factors. Both pre- and post-operatively this group's pattern of responses indicated them to be more introverted. Their mean score on the Introversion-Extraversion continuum falls outwith the 4.7-6.3 average category. Their mean anxiety score is above the average range. In this they are comparable with the temporal lobectomy group.

Considering the effect of seizure relief, it is important to note that at the time of postoperative assessment, the greatest improvement had occurred in the temporal lobectomy group, with 4 out of 5 patients being seizure free. Four of the central cases showed a marked improvement in seizure control, but this occurred in only one of the amygdalotomy group. Therefore, it does not seem reasonable to attribute the increase in extraversion and reduction in anxiety to relief from seizures, since there were fewer changes in the central group than in the temporal lobectomy group, whose personality profile showed very little postoperative change.

Table XXIII(b) gives pre- and post-operative group scores on the Hostility and Direction of Hostility Questionnaire. The postoperative drop in score noted in the temporal lobectomy group, and even more so in the central group, fails to reach statistical significance. Standard deviations are large. There is virtually no change in the amygdalotomy group.

(ii) Self-rating of mood by line marking - Visual Analogue Scale

A detailed analysis of the mean self-rating on each of the 5 lines, based on the number of days pre- and post-operatively on which the scale was completed, is presented for each individual patient in Table XL (Appendix 3).

There/

There was unfortunately wide variation in the number of days on which the scale was completed by different patients. The longer the period, of course, the more the result can be accepted as reliable. Mention will be made of the significant differences occurring on each line. First, the line with extremes marked as Happy and Depressed. Five cases showed significant changes. One left temporal lobectomy case rated himself as more depressed postoperatively. This was an expected change in view of published reports of feelings of depression following this procedure. One case in whom periods of rating were available for both immediate and long-term postoperative follow-up, rated himself as significantly more depressed following bilateral amygdalotomy. Three cases rated themselves as significantly happier postoperatively. One was a central case in whom only a very limited number of ratings were obtained, and the postoperative follow-up was very short. Of greater interest are two cases in whom exploratory procedures only were carried out. In addition to rating themselves as happier, these two cases also rated themselves as significantly more energetic and well, and one as more relaxed and better treated by others than in the "pre-operative" period.

The amygdalotomy case who felt more depressed postoperatively also felt more ill, more tired and in the long term treated worse by others compared with feeling better treated in the short term follow-up. The case of left temporal lobectomy who was more depressed postoperatively showed no significant changes on other continua, nor did the central case who felt less depressed.

Other significant changes occurred as follows: Three temporal lobectomy cases felt more tired postoperatively. The only central case/

case showing a change on this line felt more energetic, as did one amygdalotomy case. Two cases of temporal lobectomy felt more ill and one felt better. Two central and two amygdalotomy cases also rated themselves as significantly more ill postoperatively. One temporal lobectomy and two amygdalotomies felt they were treated worse by others postoperatively; one central case felt better treated.

These results can be summarised by considering significant changes as either positive or negative (positive if the patient felt "better" as measured by any of the lines). This information is contained in Table XXXIV. The proportion of mainly negative changes is the same for temporal lobectomy and amygdalotomy groups, while the positive changes occur in the central group.

Analysed in this way the results can be seen to contribute the picture emerging from patterns of responses to personality questionnaires, with the central group showing what might be classed as increased euphoria postoperatively. It is not surprising that after a major neurosurgical procedure such as temporal lobectomy, patients should feel worse and more tired. However, the line marking scale indicated that the pattern following stereotactic lesions in medial temporal areas (amygdalotomy) resembles the former more than it resembles the pattern following central lesions. Stereotactic surgery is frequently carried out under local anaesthesia and might be regarded as much less disruptive to the patient. It might have been anticipated that the difference in how patients felt postoperatively would have discriminated the stereotactic cases from the temporal lobectomy cases, rather than identifying a separate pattern in/

TABLE XXIV : Visual Analogue Scale

Summary of Post-operative Changes

Group	Positive	Negative	No Significant Change
Central	3	2	26
Amygdalotomy	1	8	11
Temporal lobectomy	1	8	16
Exploratory Procedures only	8	0	1

in the central group alone.

The finding that the highest proportion of changes occurred following non-functional exploratory procedures only is of great interest in indicating the need to take expectations of surgery into account.

(iii) Rating scales and checklists

Results obtained from the Hargreaves Nursing Rating Scale are presented first. This was the most time consuming assessment technique used, both in collection and processing of data. It was also the one creating the greatest problems in analysis. Its use was mainly for cases undergoing amygdalotomy, but some other relevant data are included. It was not possible to guarantee consistency of raters especially for long term postoperative follow-up. Nor was it possible to arrange for double ratings each day, in order to cehck inter-rater reliability, except in the special unit in which patients spent one month before and after surgery. Partly in view of these difficulties it was decided to collect ratings on this scale over two periods six months apart, on a group of mentally subnormal institutionalised patients with epilepsy. These were not patients referred for surgical treatment, and the only changes in the intervening period were in drug regime in some cases. Since the different drug regimes (folic acid and Vitamin B12) produced no consistent trends and the group of 31 are considered as a whole, the ratings obtained can usefully be compared with those of the cases undergoing surgery. The first analysis to be considered is of group results on 7 items (those relating to hostility and level of effectiveness).

In Table XXV there are three sets of comparisons of the presence or absence of disturbance on each item. Each 2 x 2 table comprises

/

TABLE XXV : Hargreaves Nursing Rating Scale - Group Results

a) Items relating to Aggression

		Amygdalotomy (pre)	Non-Surgical
Item 5 Angry Talk	0-3	2	17
	4+	5	14
		$X^2 = 0.7$ $p > .05$	
Item 6 Angry Manner	0-3	2	23
	4+	5	8
		$X^2 = 3.44$ $p > .05$	
Item 7 Un-cooperative	0-3	2	23
	4+	5	8
		$X^2 = 3.44$ $p > .05$	

TABLE XXV (contd.)

b) Items relating to level of effectiveness

		Amygdalotomy (pre)	Non-Surgical
Item 23 Effectiveness of social contacts	More 0-3	6	17
	More 4-9	1	11
		$X^2 = 0.64$	$p > .05$
Item 24 General Effectiveness	More 0-3	6	9
	More 4-9	1	6
		[illegible]	$p > .05$

an analysis of daily ratings for each patients in the group under consideration. At the left hand side of the table the amygdalotomy group (7 patients) are compared with the non-surgical group (31 patients). The comparison is based on the presence or absence of disturbance in the first period of rating for each group. The amygdalotomy patients were slightly more aggressive than the non-surgical group, and less effective (on Items 23 and 24, the higher the rating the more effective the level of functioning). However, on none of these items, was there a significant difference.

On this rating scale, as in other aspects of the study, there was greater interest in individual patient change over time than in group change. Details of analyses of such individual ratings are contained in Table XL 1 (Appendix 4). The findings are summarised in Table XXVI. The analysis was designed to investigate whether amygdalotomy resulted in any specific change in rating pattern consistently/

TABLE XXVI : Hargreaves Nursing Rating Scale

Individual Results

a) Changes in Ratings on items related to aggression

	Item 5			Item 6			Item 7			Item 8			Item 18		
Based on dichotomy:	+	-	0	+	-	0	+	-	0	+	-	0	+	-	0
Zero disturbance/Disturbance															
(i) Amygdalotomy	1	1	5	1	2	4	0	3	4	0	1	5	1	1	5
(ii) Other operations (including explorations)	2	0	2	2	0	2	0	1	3	1	0	1	0	0	4
(iii) Non Surgical cases	8	5	18	8	3	20	8	2	21	-	-	0	5	5	21
Based on dichotomy:															
Zero mild disturbance/ Moderate or severe disturbance															
(i) Amygdalotomy	1	1	4	1	1	4	0	2	5	0	2	4	0	2	5
(ii) Other operations (including explorations)	0	0	4	0	0	5	0	0	4	0	0	2	1	0	3
(iii) Non Surgical cases	2	1	15	0	0	10	2	1	11	-	-	-	3	1	14

TABLE XXVI : Hargreaves Nursing Rating Scale

b) Individual Results

Item	Group	No. of patients significantly improved	significantly worse	no significant change
21. Level of Activity	Amygdalotomy	1	2	4
	other operations	1	0	3
	Gogarburn patients	6	2	23
22. Talkativeness	Amygdalotomy	2	1	4
	other operations	0	1	3
	Gogarburn patients	2	7	22
23. Effective contact with people	Amygdalotomy	2	1	4
	other operations	2	0	0
	Gogarburn patients	7	3	21
24. General Effectiveness	Amygdalotomy	2	0	5
	other operations	2	1	1

consistently over a number of individual patients, compared with that occurring on a further period of rating, in a non-surgical group, and in addition, in other types of neurosurgical procedure in the study. For this analysis the two exploratory procedures were grouped with one central case and one temporal lobectomy. The top half of Table XXVI(a) indicates significant changes in the presence or absence of aggressive disturbance. Considered in this way the results reflect the group changes described above. Using the Fisher test for small groups, the difference between the increase/decrease in aggression in the non-surgical cases and in the amygdalotomy group reaches the .05 level of significance for Item 7 (stubborn, physically resistive).

In view of the higher level of aggressive disturbance ~~already~~ suggested. ~~demonstrated~~ in amygdalotomy cases (in Table XXV), it was considered desirable to have an analysis which took account of level of disturbance. Cases in whom there were no ratings above three (i.e. who did not show moderate or high level of disturbance on any day in the rating period) were excluded. This left only half of the non-surgical group, but did not alter the composition of the operative groups to any extent. This analysis is shown in the lower half of Table XXVI (b). The pattern is similar, but with even fewer cases showing significant changes.

Thus, considering all the data available from this technique of assessment, significant decreases in hostile behaviour were shown in a minority of cases following amygdalotomy, but on only the item related to being stubborn did this distinguish them from a non-surgical group. Similar increases in level of effective contact with people, and in general effectiveness, occurred in a minority of cases/

HARGREAVES NURSING RATING SCALE.

Patient S.D. (Female)

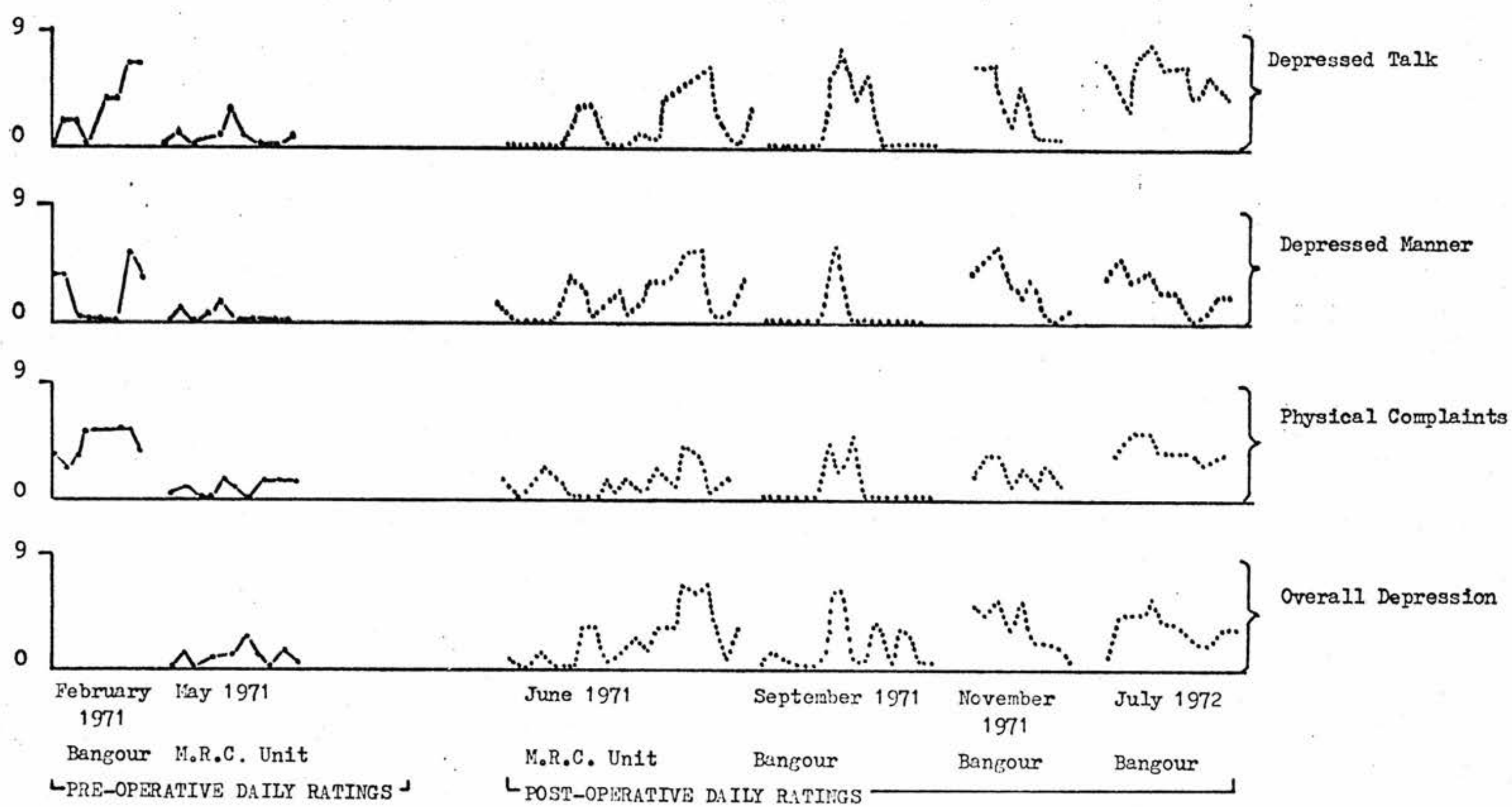

Fig.18. H.N.R.S.- Depression, Items 1-4. Amygdalotomy patient. A 10 point rating scale is used with 0 = no disturbance, and 9 = extreme disturbance.

HARGREAVES NURSING RATING SCALE. Patient G.C. (Male)

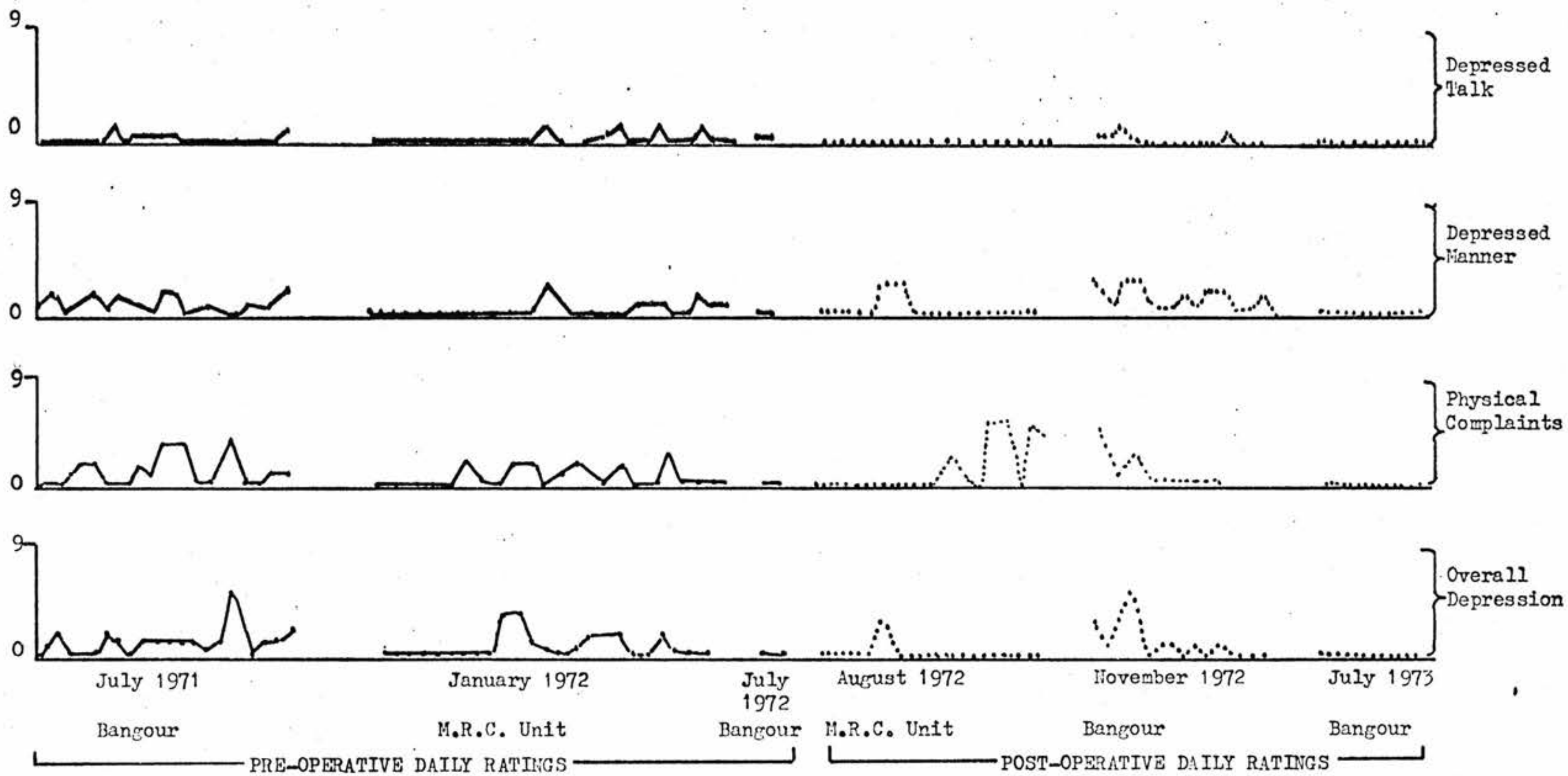

Fig.19. H.N.R.S.- Depression, Items 1-4. Amygdalotomy patient. A 10 point rating scale is used with 0 = no disturbance, and 9 = extreme disturbance.

HARGRIEVES NURSING RATING SCALE. Patient S.D. (Female)

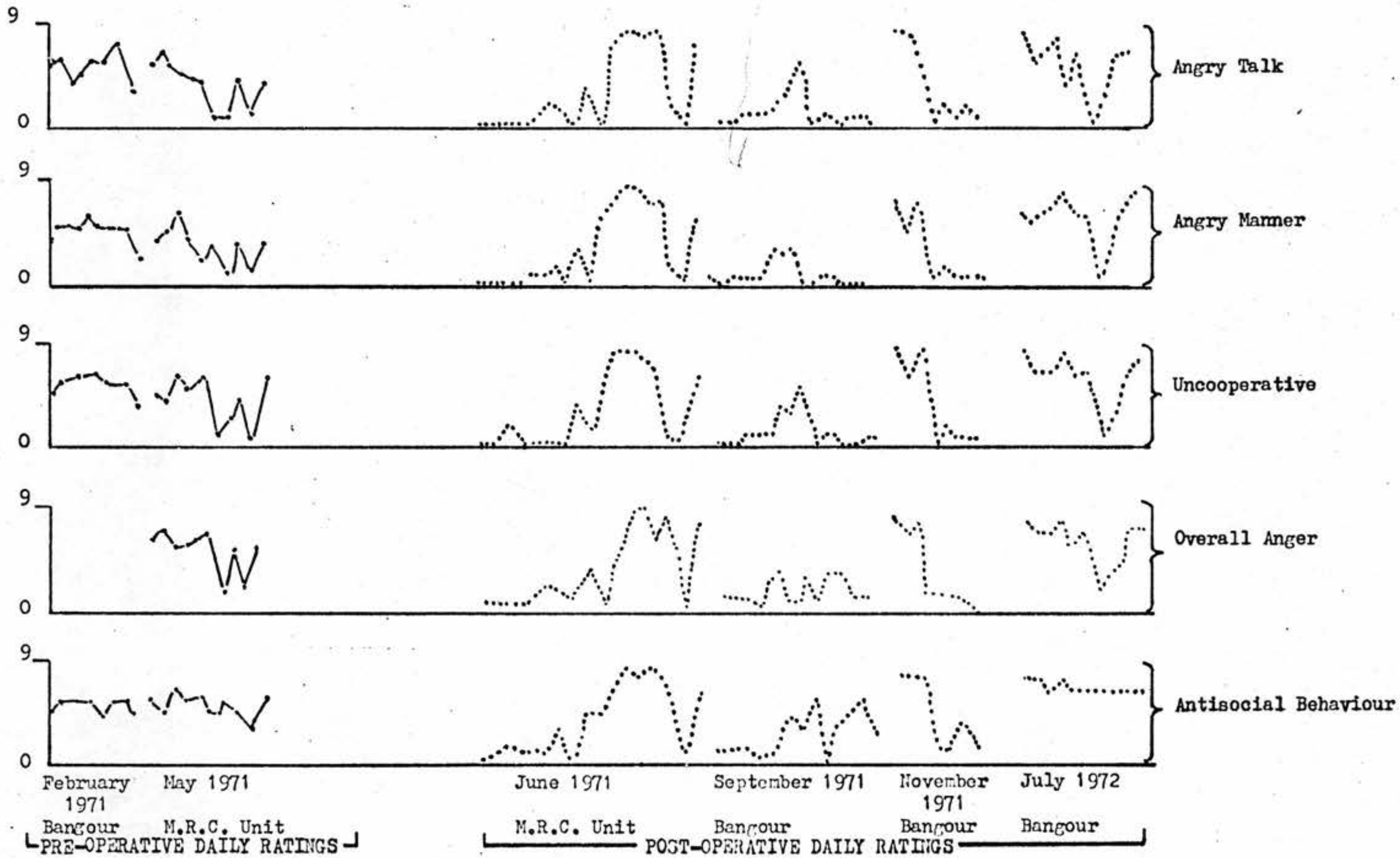

Fig.20. H.N.R.S.– Hostility, Items 5-8,18. Amygdalotomy patient. A 10 point rating scale is used, with 0 = no disturbance, and 9 = extreme disturbance.

HARGREAVES NURSING RATING SCALE.

Patient G.C. (Male)

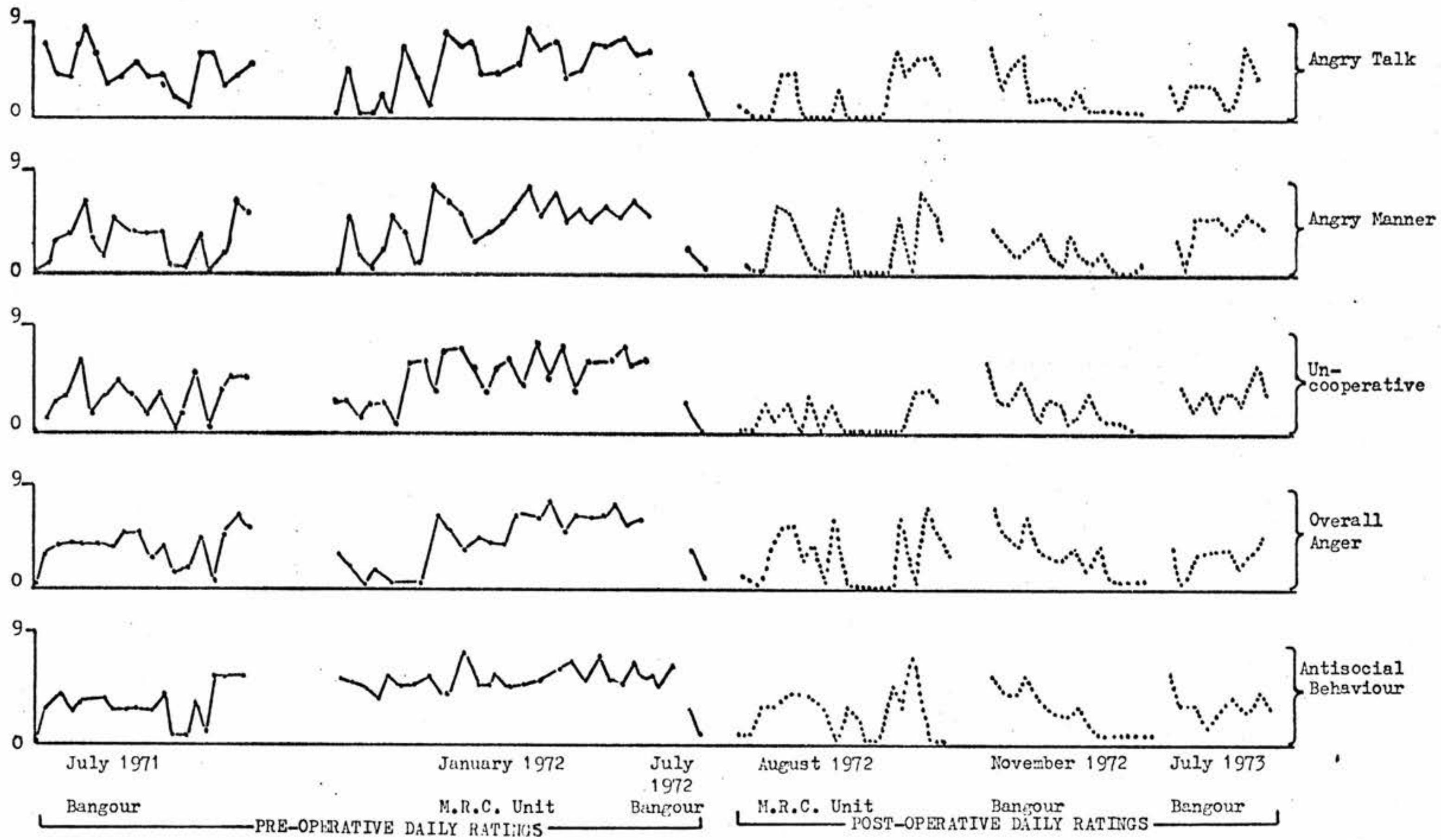

Fig.21. H.N.R.S.- Hostility, Items 5-8,18. Amygdalotomy patient. A 10 point rating scale is used, wiht 0=no disturbance, and 9 = extreme disturbance.

HARGREAVES NURSING RATING SCALE.

Patient S.D. (Female)

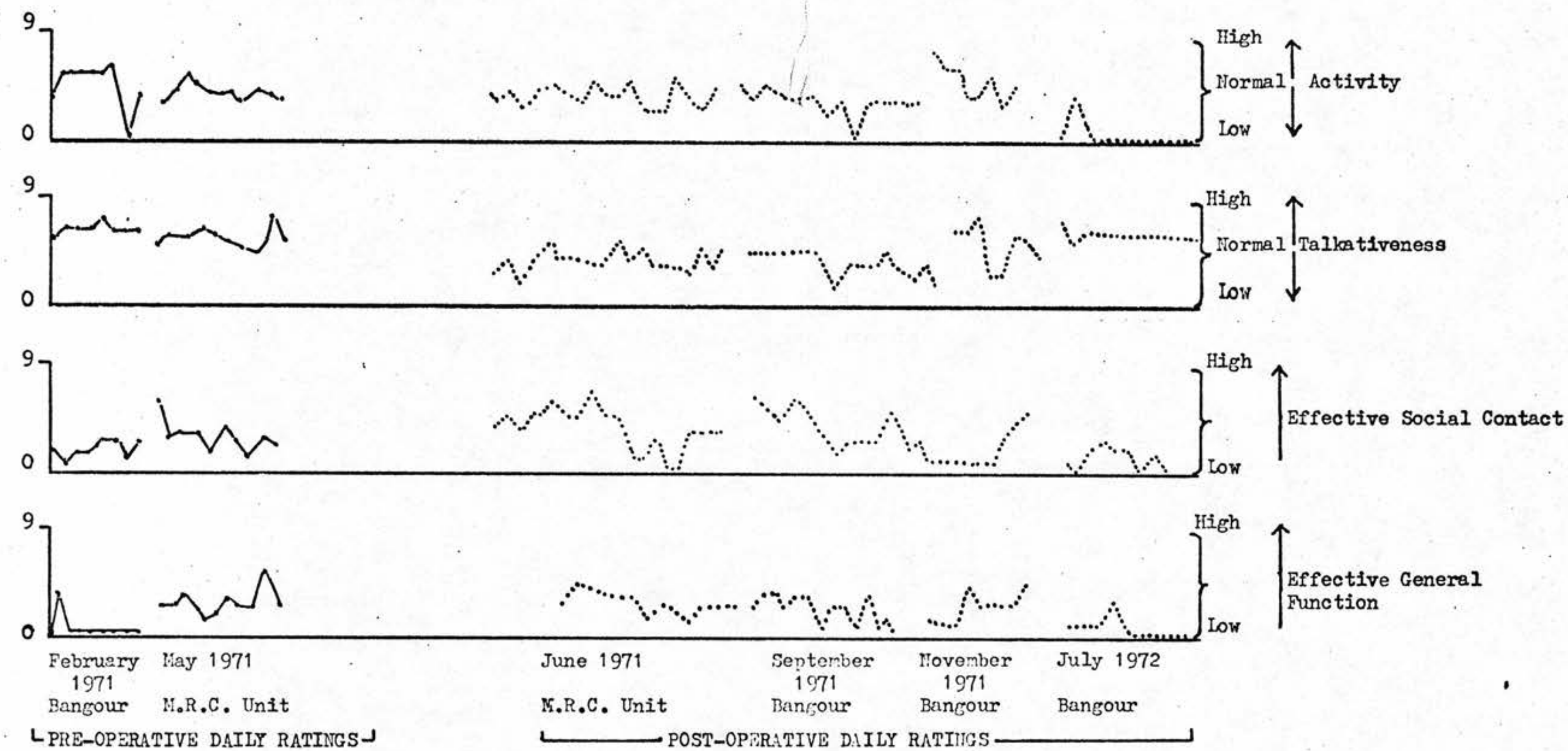

Fig.22. H.N.R.S. Amygdalotomy patient. Items 21, activity, and 22, talkativeness, are bipolar. On Items 23, Effective Social Contact, and 24, Effective General Function, the higher the rating, the more effectively the patient is functioning.

HARGREAVES NURSING RATING SCALE. Patient G.C. (Male)

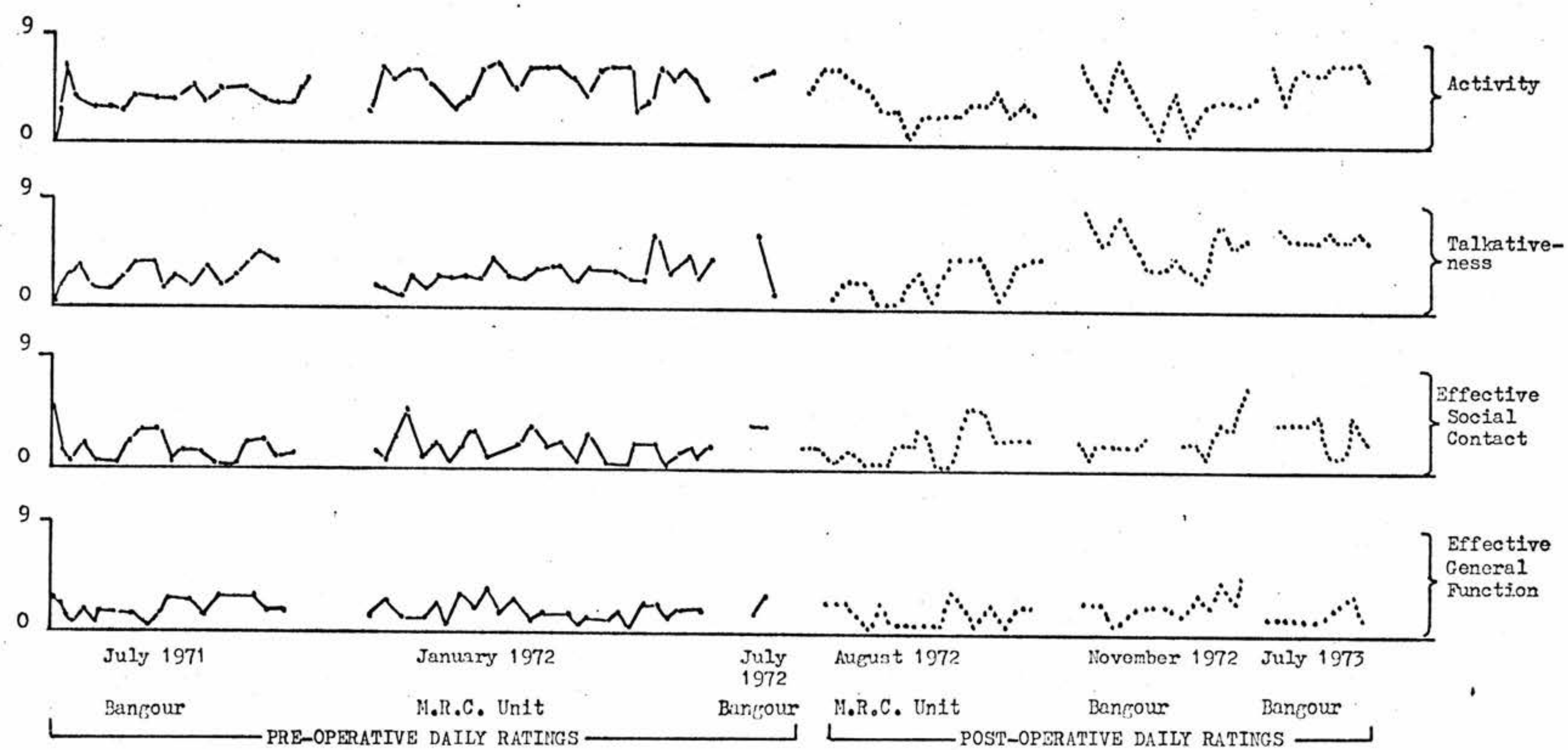

Fig.23. HNRS Amygdalectomy patient. Items 21, Activity, and 22, Talkativeness, are bipolar. On Items (23), Effective Social Contact, Effective General Function, (24), the higher the rating, the more effectively the patient is functioning.

cases in all groups.

In Figures 18-20 the daily ratings on the items analysed above, and a number of others, are plotted for 2 cases. These show that marked daily fluctuations make it difficult to identify trends within periods of rating or differences between periods. The generally low ratings on items relating to depression in the male are contrasted with the level of disturbance noted on items related to hostile behaviour.

In contrast with the complexity of administration and data processing in the Hargreaves Nursing Rating Scale is the simplicity of the checklist method to be discussed. Table XXVII presents the results in a number of different groups on Part II of the Adaptive Behaviour Scale. It was decided that the most meaningful comparison was between pairs of scores for individual patients by the <u>same</u> rater (or if this was not possible, a rater in the same type of environment, i.e. nurse/nurse or parent/parent). Thus for one individual there might be more than one difference score, depending on the number of raters pre- and post-operatively. Group results were based on means and standard deviations of such difference (or change scores). The group means were then subjected to an analysis of variance technique. This did not yield a statistically significant value for any of the 14 areas of maladaptive behaviour in the scale. As was found in analysing postoperative change in cognitive function, the degree of variation within groups prevents significant differences being demonstrated, even where mean changes look different on inspection. In addition, pairs of groups were compared using a 't' test. The significant differences emerging are given in Table XXVII(b). The only item on which (either short or long term) amygdalotomy produced significantly/

TABLE XXVII (a) : Adaptive Behaviour Scale - Group Results, based on difference between raw scores pre and post-operatively

Group	A-Violent Behaviour		B-Antisocial Behaviour		C-Rebellious Behaviour		J-Self-Abusive Behaviour	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Amygdalotomy 1. Short term 7 patients, 13 ratings	-5.2	9.6	-7.4	11.9	-10	7.1	0.3	1.7
2. Long term 7 patients, 15 ratings	-7.4	6.8	-6.2	8.9	- 7.9	7.0	0	2
Other procedures 3. For Epilepsy 4 patients, 10 ratings	-6.3	11.1	-7.9	16.1	-9.2	13.8	-0.5	1.1
4. For Behaviour Disorder 5 patients, 7 ratings	-6	6.4	-4.1	15.4	-3	5.5	0.1	1.1
5. Explorion only 2 patients, 4 ratings	-9.2	10.3	-6.2	4.8	-2.75	2.2	-2	1.8
Non-surgical 9 patients, 12 ratings	-0.5	11.3	1.75	15.3	-0.25	10.2	-0.2	1.9
F Ratio	0.93		1.02		2.08		1.25	
p	$>.05$		$>.05$		$>.05$		$>.05$	

TABLE XXVII (contd.)
(b)

Group	E-Withdrawal		K-Hyperactivity		L-Sexually Aberrant Behaviour		M-Psychological Disturbances	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Amygdalotomy								
1. Short term 7 patients, 13 ratings	0.9	6.7	-0.7	2.4	-2.8	3.8	-2.6	3.8
2. Long term 7 patients, 15 ratings	-2.4	3.4	-1.1	2.1	-0.7	1.9	-3.3	5.5
Other procedures								
3. For Epilepsy 4 patients, 10 ratings	-0.7	1.1	-1.4	3.1	-1.4	3.8	-6.4	8.8
4. For Behaviour Disorder 5 patients, 7 ratings	0.8	5.1	-1.8	4.8	-0.8	1.2	-3.3	6.4
5. Exploration only 2 patients, 4 ratings	-3.5	4.1	-0.7	0.9	-0.25	0.5	-11.5	8.9
Non-surgical 9 patients, 12 ratings	-0.8	3.4	0.2	2.9	0.3	6.5	-0.3	12.6
F Ratio	1.32		0.58		0.93		1.4	
p	$>.05$		$>.05$		$>.05$		$>.05$	

TABLE XXVII (contd.) Adaptive Behaviour Scale

c) Significant differences between groups

Item	Groups	't'	d.f.	p	Difference
C	1 and 6	2.79	23	0.02	Group 1 show a greater decrease in rebelliousness
J	1 and 5	2.33	15	0.05	Group 5 show a greater decrease in self-abusive behaviour
M	1 and 5	2.9	15	0.01	Group 5 show a greater decrease in psychological disturbances

significantly more benefit than no operation, was Item C (rebelliousness).

It is of great importance to note that violent and destructive behaviour (Area A), and antisocial behaviour (Area B), as well as showing marked mean score drop in both short and long term follow-up of amygdalotomy, also showed a large drop in all other groups, except the non-operated group. The two cases in whom an exploratory procedure only was carried out also show a marked postoperative drop. Compared with the amygdalotomy group the former group also demonstrated significantly greater decline in self-abusive behaviour and in the area labelled "psychological disturbances" (including reaction to frustration and sudden mood swings). On this item, the non-operated control group were also significantly less disturbed on re-assessment than the amygdalotomy cases. While raw scores were used in the above analyses, data also became available (Nihira, personal communication) to enable consideration of the distribution of scores, and of change, in the present sample, in relation to the population used in standardising the scale. This comparison is presented for each operated case for whom the scale was completed, for 5 areas of maladaptive behaviour, in Figures 21-25. Most recent follow-up was selected for which there was a comparable pre-operative rating (viz. nurse/nurse or parent/parent). If this still left a choice, then the most disturbed pre-operative rating was selected and compared with the post-operative score by the same rater. A high proportion of cases are shown to be more disturbed pre-operatively, than 90% of the standardisation sample (institutionalised, mentally retarded patients).

This graphic representation is seen as confirming the results discussed/

Fig. 4. ADAPTIVE BEHAVIOUR SCALE

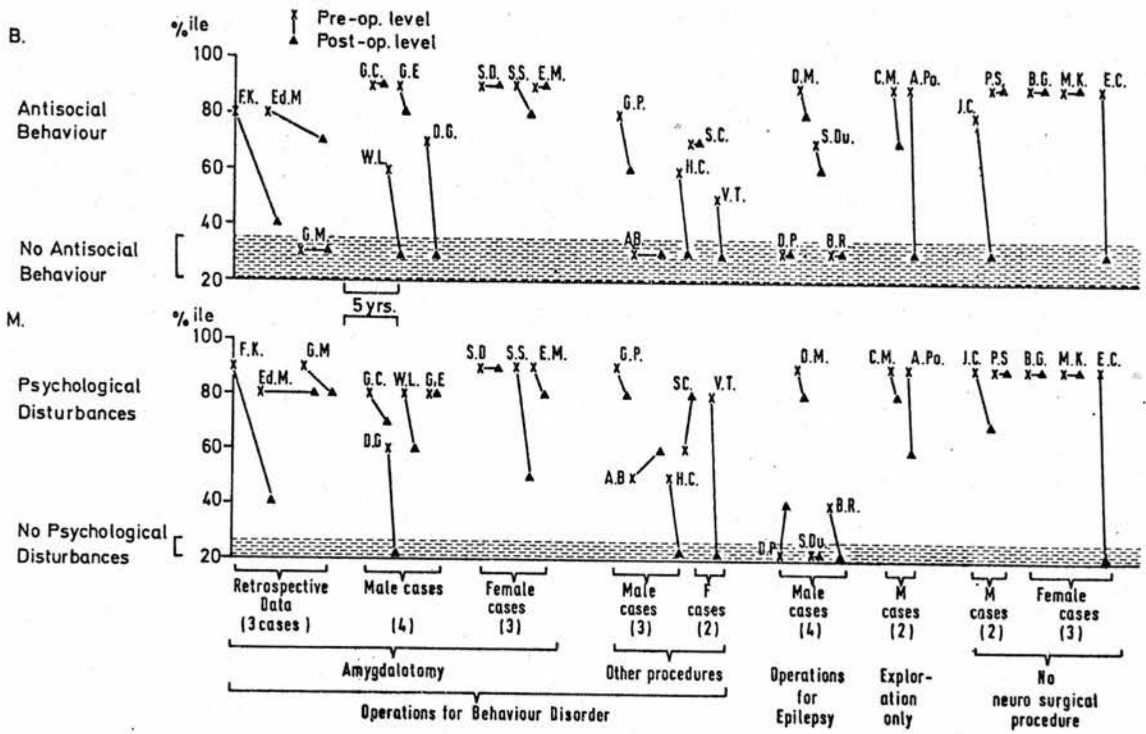

Fig.24.

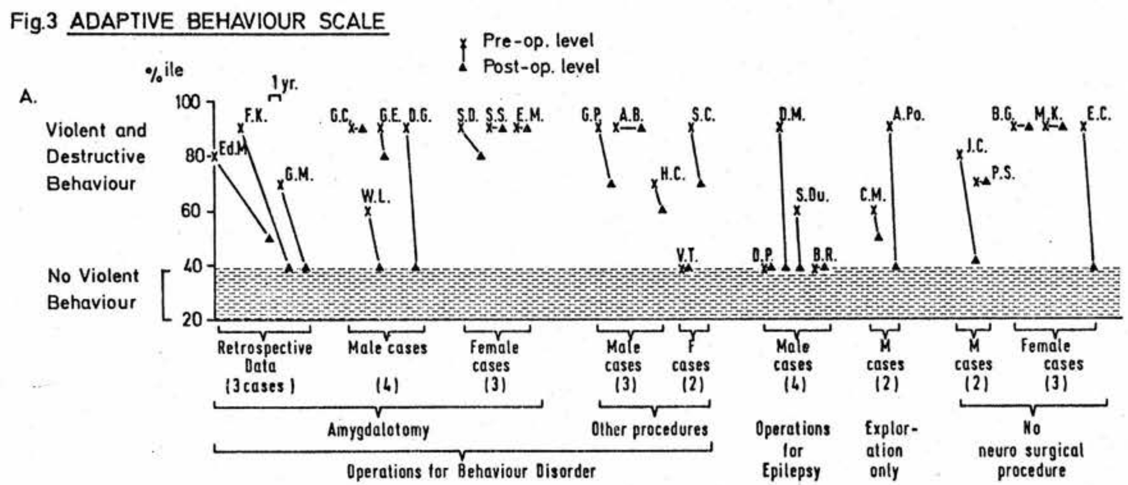

Fig.25(a).

Fig.24,25(a&b). Adaptive Behaviour Scale. Pre- and post-operative levels in five areas of maladaptive behaviour. The vertical axis indicates percentile rank, the stippled area the percentage of an equivalent population obtaining zero scores. Length of follow-up is indicated along the horizontal axis, each case being plotted separately.

Fig.3. ADAPTIVE BEHAVIOUR SCALE

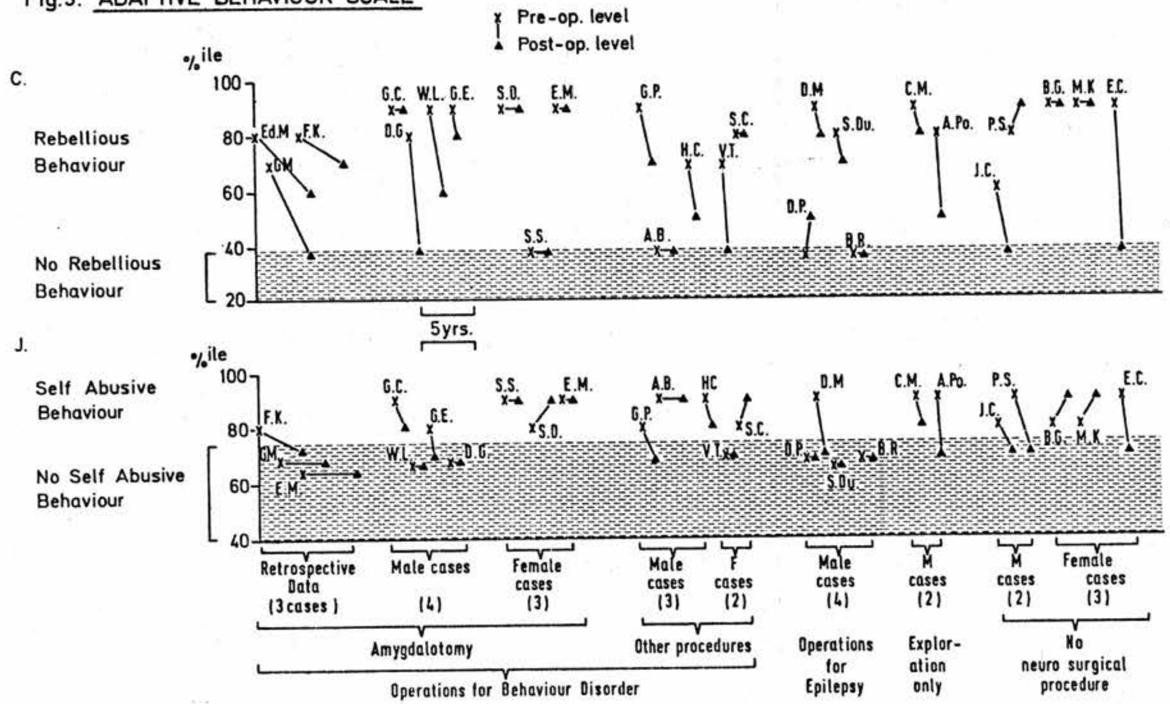

Fig.25(b). see legend Fig.25(a).

discussed above, in that there are many cases showing significant improvement in behaviour. It is extremely important to note, particularly where follow-up is relatively long term, that the norms from which these figures are derived are age-based norms. Thus where improvement is shown in an individual, this has taken account of expected changes with maturation.

Improved cases tend to be distributed over all types of neurosurgical procedure, including exploratory procedures only, and also occur in the non-surgical group. These figures also show that amygdalotomy tends to be less effective in reducing level of aggressive behaviour in female than in male cases. This is also an appropriate point at which to consider the implications of intellectual level in relation to the effect of neurosurgical intervention on disturbed behaviour. Many mentally retarded patients showed significant improvement (three such are D.M., S.Du and D.G.). Where mental age was estimated as below two year level, some areas of this scale (such as rebellious behaviour) were less applicable than Area A (violent and destructive behaviour). There was no improvement in this in two cases (S.S. and A.B.) and only slight improvement in one case (H.C.).

Results, for the most recently operated case of amygdalotomy, of a less global assessment method, based on 5 minute periods of observation, are presented in Table XXVIII. This patient showed a more effective pattern of behaviour postoperatively, with a significant drop in the frequency of aggressive responses observed and an increase in co-operative behaviour and social contacts. It is important to note that this case was also rated on both the Hargreaves Scale and the Adaptive Behaviour Scale as very much less disturbed in the short term/

TABLE XXVIII : Behavioural Observation on an Individual Patient (G.E.)

No. of 5 minute periods of observation pre-operatively 170

post-operatively 432

[In body of Table:
Occurrence of item noted as +
Absence of item noted as -]

Item		Pre (Frequency)	Post (Frequency)	X^2	p
a) Items related to aggression					
Hit	+	32	9		
	-	138	423	51.2	.001
Kick	+	19	1	42.1	.001
	-	151	431		
Push, pull	+	34	19	35	.001
or hold	-	136	413		
Snatch	+	38	18		
object	-	132	414	45.6	.001
Chase	+	5	5		NS
	-	165	427	1.4	
Threaten	+	27	14		
(gesture)	-	143	418	28.7	.001
Throw	+	3	1	-	
objects	-	167	431	2.3	NS
b) Inappropriate					
sexual	+	11	22		
contact	-	159	410	0.2	NS
c) Vocalisation					
Spontaneous	+	30	347		
speech	-	140	85	202	.001
Reply	+	83	398		
	-	87	34	139	.001
Verbal /					

TABLE XXVIII (contd.)

Item		Pre (Frequency)	Post (Frequency)	X^2	p
c) Vocalisation (contd.)					
Verbal	+	28	12		
Threat	-	142	420	34.6	.001
Swear	+	13	53		
	-	157	379	2.2	NS
Incoherent	+	11	66		
	-	159	366	7.7	.01
Gives orders	+	39	33		
	-	131	399	25.6	.001
Refuses	+	47	44		
"No!"	-	123	388	27.6	.001
d) Activity					
Sleeping		28	0		
awake		142	432	70.9	.001
lies	+	13	7		
(throughout)	-	157	425	11.9	.001
sits	+	38	132		
(throughout)	-	132	300	4.3	.05
walks	+	76	234		
	-	94	198	4	.05
leaves room	+	54	158		
	-	116	274	1.0	NS
any	+	27	111		
co-operative activity	-	143	321	6.1	.02
plays with	+	15	26		
toy	-	155	406	1.1	NS
uses	+	26	149		
equipment	-	144	283	20.8	.001
manipulates	+	33	84		
fixtures	-	137	111	.01	NS

TABLE XXIX : Pre and Post Operative Performance on Experimental Measures

a) Pursuit Rotor - Index of Effect of Failure

		Difference Score	SD
Central cases (4)			
	Mean	-.14	.21
	SD		
Amygdalotomy (2)			
	Mean	-.11	.18
	SD		
Temporal Lobectomy (2)			
	Mean	-.07	.14
	SD		

d.f. = 2.5 F Ratio (Variance of difference Scores by type of operation) = 0.04 p > .05

b) Mirror Drawing - Persistence on a Frustrating Task

		Difference Score	
Central cases (4)			
	Mean	-2.8	5.4
	SD		
Amygdalotomy (2)			
	Mean	-0.4	2.7
	SD		
Temporal Lobectomy (2)			
	Mean	0.8	1.2
	SD		

d.f. = 2.5 F Ratio (Variance of difference Scores by type of operation) = 0.5 p> .05

term, although this improvement was less marked in the longer term. This case was a male adolescent patient of severely subnormal intelligence. In addition to the regular pattern of destructive negative behaviour, there were infrequent violent assaults of a serious nature (three such had occurred pre-operatively) as a result of which the subnormality hospital considered that they could no longer contain this patient. The assessment procedures used in this study were mainly designed to measure the former while only the Adaptive Behaviour Scale was likely to pick up the infrequent severe assaults. The immediate postoperative improvement in effectiveness was followed by a further violent assault, which led to the patient's transfer from a subnormality hospital to a state institution. This information is included since it demonstrates the need to consider assessment on a broader basis than the narrow standpoint of readily quantifiable data. This point is considered further in (vi) below.

First, however, two further aspects of the study require mention.

<u>(iv) Experimental measures</u>

Table XXIX is presented tentatively, with results from two of the three standard situations. The control study (Appendix I) has cast doubts on the validity and reliability of the Pursuit Rotor technique. With the very small numbers tested pre- and post-operatively it can be mentioned only briefly that the central lesion patients were less affected by failure and less persistent post-operatively.

<u>(v) The study of effects of amygdaloid stimulation</u>

Table XXX gives case details of 6 patients on whom amygdalotomy was carried out under local anaesthesia. Detailed tape recordings were/

Details of six cases undergoing amygdalotomy under local anaesthesia

Patient	Sex	Age at operation (years)	Operation	Date	Seizure type	EEG focus	Main presenting complaints	Intelligence
W.L.	M	34	Bilateral	14.7.71	? Psychomotor	No EEG abnormality	Aggressive behaviour and drinking problem	Average
H.F.	M	42	Unilateral left (previous right-sided lesion)	4.5.70 24.6.67	Focal	Bilateral temporal abnormality (pre first operation)	Aggressive behaviour and drinking problem	Average
W.G.	M	29	Bilateral	23.10.70	Major + temporal lobe fits	No significant abnormality	Aggressive behaviour and drinking problem	Average
D.G.	M	17	Bilateral	26.8.71	Jacksonian + major	Left occipital focal disturbance	Aggressive behaviour (to parents only)	Severely subnormal
G.M.	M	44	Bilateral	27.1.70	Temporal lobe	Sphenoidal EEG Right inferior temporal disturbance	Aggressive behaviour (self-reported, never observed) and drinking problem	Average
E.M.	F	18	Bilateral	18.5.72	None	None	Behaviour disturbance (with violent and self-mutilative behaviour	Severely subnormal

Table XXX

Tabulated results of behaviour during stimulation and coagulation in six patients

Description of behaviour	No. of patients in whom this response was obtained	
(1) Aggressive behaviour		
(a) Swearing	2	
(b) Shouting, sounding angry	3	
(c) Threat of violence	1	
(d) Restless, destructive behaviour	4	
(2) Emotional, upset, tearfulness	1	These expressions of emotions were all associated with periods of confusion
(3) Other expressed emotions		
(a) Anxiety	1	
(b) Guilt	2	
(c) Embarrassment	1	
(d) Jealousy	1	
(4) Verbalized desire for 'flight', 'escape'	3	
(5) Expressed fatigue	2	
Signs of fatigue	4	
(6) Confusion	3	
(7) Disorientation		
(a) Place	1	
(b) Time	1	
(8) Unresponsiveness	5	
(9) Incoherent speech	4	
(10) Automatic speech	2	
(11) Automatic behaviour	4	
(12) Autonomic/visceral		
(a) Flushing	4	
(b) Thirst	2	
(c) Butterflies in stomach	1 (normal seizure pattern)	
(13) Motor		
(a) Upper limb movement	3	
(b) Jaw movement	2	
(c) Slurring of speech	3	
(14) Sensory		
(a) Visual		
(i) Diplopia	2	
(ii) c/o everything going black	1	
(b) Smell/taste	1	
(c) Feeling of electric shock, tingling	1	
(15) Seizures		
(a) Typical	3	
(b) Atypical	0	

Table XXXI

were obtained during stimulation as the probe advanced towards the target and at the target site. The behavioural responses obtained are summarised in Table XXXI.

The most significant (and the most dramatic) effect of stimulation has been the eliciting of a range of aggressive responses from coherent, appropriately directed verbal responses (speaking to surgeon, "I feel I could get up and bite you") to uncontrolled swearing and physically destructive behaviour. While all these patients had a history of abnormally aggressive behaviour, during inpatient investigations, psychological testing, etc., such behaviour as occurred during stimulation was not observed at all. In 4 patients a similar pattern of restless behaviour was obtained which included tearing at drapes and clothes, moving hands up towards the stereotactic frame and trying very forcibly to remove this frame. This characteristic pattern occurred during coagulation as well as during stimulation in 2 of these 4 patients. It appeared purposive but had an automatic quality. It was not susceptible to modification as a result of external stimulation, i.e. verbal commands to move the hands from the frame or not to tear off the gown, and force was required in 2 cases to prevent the stereotactic frame being removed by the patient who before and after these episodes appeared fully aware of the situation and refrained from touching the frame or from interfering with the operative procedure in any way or from interfering with the drapes, etc.

Two patients expressed other emotions during what appeared as periods of confusion. Three patients expressed a desire to get away. The significance of this, which might be termed 'flight' behaviour, in/

Record of stimulation responses: Stimulation of amygdala (patient W.L.; date, 13 July 1971; side, right)

Time	On/off	Frequency (Hz)	Voltage	Comments made and questions put to patient	Patient's responses: Verbal	Patient's responses: Observations
	At target					
0	On	50	3	Tell us if you feel anything.		7 sec delay—incoherent response.
0·12				What's happening?		6 sec delay.
					Yes.	
0·22				Mr L.	Yes.	
				Are you awake?	Yes.	
				How are you feeling?	OK.	
				Any funny feeling?	Yes, just	3 sec pause.
0·30				Just what?		3 sec pause. Long sigh.
					Just I'm getting sick of all this.	
0·35	Off			How are you now?	Just the same.	Still sounds angry.
0.40	On	5	4·5		My leg.	2 sec delay and then face flushing.
0.43					I can hardly speak*****	Patient swearing.
0.55				What's the matter?		10 sec delay.
					Everything going black.	
				What do you feel now?		3 sec delay.
1.10			5		I just want to get***** out of here.	Patient swearing, shouting very angrily.
1.20				That's OK.		
	Off			All right?	Yes.	
1.50				Did you feel angry?	Aye, I did.	Patient sounds surprised.
				Do you feel that now?	No, I don't feel that now.	

Table XXXII

in relation to known patterns following amygdaloid stimulation in animals in whom distinct patterns of flight, defence and attack responses have been observed (Kaada, 1972) is of some interest. No pleasurable emotional feelings and no responses connected with sexual behaviour were identified in any of our patients during stimulation or coagulation.

A comparison of the effects obtained during stimulation and coagulation of the amygdala with the features of psychomotor seizures (Chatrian and Chapman, 1960) shows them to be very similar. Where seizures occurred during the stimulation procedure these were of a similar nature to the patients' current seizure pattern (D.G., W.G., G.M.). Two of the patients reported these as identical and in the third patient they were observed to be identical. The question of whether the unresponsiveness noted in 5 of our patients was in fact no more than the occurrence of seizures was raised but there were several instances of unresponsiveness in the two patients in whom there was no history of clinical seizures. During some of these periods of unresponsiveness the patient would at some times respond to non-verbal commands. At other times there was no response and not even an orienting to the source of the stimulus. These aspects ruled out the possibility that we were seeing no more than speech arrest frequently reported during stimulation of the peri-amygdaloid area. It is of some interest that the unresponsiveness occurred in 2 patients at exactly the same location at which verbal aggression and restlessness were previously or subsequently elicited. No clear-cut pattern has as yet emerged between the onset of the stimulus and the occurrence of the response, or of persistence of response after cessation/

cessation of stimulus. Some responses occurred within 3 seconds of the onset of the stimulus and some responses persisted one minute after the cessation of the stimulus.

In one of the two cases in which vehement swearing occurred, this was of sudden onset, 30-45 seconds after stimulation commenced, on 3 separate occasions. The disturbance lasted for 15-30 seconds and the patient became placid 5-30 seconds after cessation of stimulation. On one occasion the patient was asked, 30 seconds after cessation of the stimulus, if he had felt angry. He agreed that he had been angry, but that he no longer was, and he sounded very surprised (Table XXXII).

(vi) As an addendum to formal psychological assessment procedures, it is important to consider aspects of general effectiveness in the group and behaviour in relation to seizures. In Table XXXIII pre- and post-operative patterns of institutionalisation and occupation are detailed. Pre-operatively, a higher proportion of cases in the central and temporal lobectomy groups were living at home than in the amygdalotomy or amygdalectomy groups. The slight postoperative increase in the proportion hospitalised is distributed over all surgical procedures.

In Table XXXIII(b) it can be seen that a large number of patients were not engaged in any occupational activity. The pattern was similar for all main operative groups, as was the slight postoperative improvement in the position.

Table XXXIII(c) gives an indication of the effect of the three main neurosurgical procedures on seizure frequency. This shows that temporal lobectomy was most effective in achieving complete relief of seizures, while all three procedures were effective in reducing the/

TABLE XXXIII : Social effectiveness of Operated Cases

a) Residence

	At Home		Institution		Died
	Pre	Post	Pre	Post	
1. Central cases (13)	12	11	1	2	
2. Amygdalotomy (18)	12	10	6	8	
3. Temporal Lobectomy (23)	20	17	3	5	1
4. Amygdalectomy	2	1	3	4	
Total	46	39	13	19	1

b) Occupation

	Open		Sheltered		Housewife		School		None	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Pos
1. Central cases (13)	3	2	0	1	3	2	2	2	6	6
2. Amygdalotomy (18)	4	5	2	4	1	1	1	0	10	8
3. Temporal Lobectomy (23)	6	8	1	2	4	4	2	1	10	7
4. Amygdalectomy (5)	-	-	-	-	-	-	1	1	4	4
									**	Died
										1

TABLE XXXIII (contd.)

c) Fit Frequency Pre and Post Operatively in Main Operative Groups

	Pre-op.				Post-op.			
	Daily or more	Weekly	Monthly or less	None	Daily or more	Weekly	Monthly or less	None
1. Central Cases (13)	5	6	2	0	2	7	3	1
2. Amygdalotomy (18)	6	8	0	4	1	9	3	5
3. Temporal Lobectomy (13)	6	8	2	1	1	2	6	8

TABLE XXXIV : Change on Adaptive Behaviour Scale and Seizures

	A-Vident Behaviour Mean Change	B-Antisocial Behaviour Mean Change	C-Rebellious Behaviour Mean Change	M-Psychological Disturbances Mean Change
1. Seizure Frequency Reduced (4) (11 ratings)	-9	-9.8	-10.8	-6.3
2. Seizure Frequency Unchanged (5) (6 ratings)	-7.5	-10.8	- 8	-1
3. No Seizures (6) (13 ratings)	-6.1	-3	- 4.9	-3.8
F Ratio	0.3	1.6	1.03	1.16
p	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$

the frequency of seizures in a proportion of cases.

These data were utilised in the final analysis undertaken in the study. The Adaptive Behaviour Scale had failed, by and large, to identify specific patterns of behavioural change associated with particular neurosurgical procedures. Could this be because another variable, i.e. change in seizure pattern, was a more important factor? Table XXXIV analyses change in four areas of the Adaptive Behaviour Scale, by regrouping patients. This was based on whether there was (a) marked seizure relief postoperatively (change of category in Table XXXIII(c)), (b) no change in seizure pattern, or (c) no frank seizures pre-operatively. An analysis of variance failed to yield a statistically significant result for any of the four areas. Thus it could not be concluded that cases in whom fit pattern changed showed a consistent change in behavioural disturbances which distinguishes them from those in whom seizures persisted pre-operatively, or in whom there were no frank seizures.

(vii) Summary of pre- and post-operative assessment of personality and behaviour

Considering first the small group of more effective patients who were able to complete questionnaires and the line-marking scale, there were no indications that amygdalotomy resulted in reduction of hostility or in better adjustment as indicated by personality profile. With these techniques the greatest effect was demonstrated in the central lesion group. This resembled the effects of lesions in frontal brain areas with reduction in anxiety and hostility, and increased disinhibition, extraversion and sense of well-being (line-marking scale). Both temporal lobectomy and amygdalotomy patients tended/

tended to feel worse postoperatively, while two cases in whom the surgical procedure was only an exploratory one, felt better than any other group postoperatively.

When the results obtained through the use of daily ratings (Hargreaves Nursing Rating Scale) and a more global assessment (Adaptive Behaviour Scale) are considered, a number of cases who underwent amygdalotomy showed significant improvement. However, comparison of the results in groups of patients with epilepsy undergoing other neurosurgical procedures revealed a similar pattern of improvement. This was less unexpected than the further comparison with cases in whom only an exploratory procedure or no surgery at all was carried out. Some patients in these groups also showed improvement in a number of areas of behavioural disturbance. Changes persist when maturational effects are taken into account. One effect which appears more specific to amygdalotomy is a drop in the frequency of stubborn, physically resistive behaviour (Hargreaves) with an associated postoperative decrease in rebelliousness (Adaptive Behaviour Scale), when these groups are compared with the non-surgical group.

For the group as a whole, there was no indication that reduction in behavioural disturbance was specifically associated with reduction in seizure frequency. When measures of general effectiveness are considered, few major changes are noted. Improvement is represented by slightly more patients being engaged in some form of occupational activity. On the other hand, impairment is indicated by the fact that slightly more patients are hospitalised postoperatively.

DISCUSSION

DISCUSSION

The main achievement of this study lies in its observations, rather than in conclusive findings. A current issue of the British Medical Journal asks of surgeons, "Do we know what we are doing?" If the claim made is accepted, that the surgeon is uncritical because "he is a doer, rather than an observer", then he and the psychologist should complement each other. In this field the psychologist is, par excellence, the observer rather than the doer.

Unfortunately, this study has demonstrated that, although the psychologist may be better equipped than others to evaluate behaviour, the complexity of human behaviour, and the lack of reliable instruments to measure important aspects of it, tend to make applied research unsatisfactory. There is a wide gap between theoretical concepts of brain-behaviour relationships, and their demonstration in patients. This is less true of aspects of cognitive function than it is of emotional behaviour and long-standing personality characteristics.

It must be remembered that if the psychologist abandons the attempt to do applied research, the problem is not solved. In the field of the present study, patients and neurosurgeons remain, operations continue and will be evaluated on the basis of clinical impression.

One of the principles governing this study was that it should apply formal psychological assessment procedures, where previously evaluation had been less objective and less quantifiable. A corollary of this was that the study should seek primarily to answer questions about the efficacy of neurosurgery, rather than aiming to contribute to/

to the theory of brain-behaviour relationships. This meant that it was necessary to provide information on all cases, including those regarded as "untestable" in other circumstances. It would be of little use to the neurosurgeon if the effects of the operation were evaluated only in patients who were easily assessed. One consequence of this decision has been the diversity of assessment techniques used, to cover as many aspects of psychological functioning as possible. This has made the study difficult to handle in a number of ways. Not least, this has been found in analysing the wealth of data accumulated, albeit on a relatively small number of patients. It has been necessary to restrict the results presented, to manageable proportions.

Careful scrutiny of published studies initially thought to be comparable with the present study revealed that a surprising number were retrospective studies. These either utilised data from case notes or were based on follow-up interview with patient or relatives or both. There are numerous advantages in the prospective design of the present study. One of the most important is that it avoids asking anyone to make a subjective judgment about whether or not the patient "is better." Where raters or self-report techniques have been used, measures of patient behaviour at that point in time are made, and repeated at different points in time, thus providing a more objective measure of change.

This study afforded an unusual opportunity to carry out a prospective investigation of psychological function in patients undergoing different neurosurgical procedures, exploratory procedures only, and a similar study of patients referred but not coming to surgery. There are remarkably few published studies of assessment and reassessment of behaviour/

behaviour in such deviant groups, outside institutions, in the absence of intervening treatment.

(i) At the outset of the study it was postulated that follow-up should be as long as possible within the time span of the project. Assessments made in the immediate postoperative period have sometimes been regarded as valueless because of surgical sequelae (tissue swelling, irritation, general depression of conscious level). These can cause psychological changes of a generalised type, not associated with the specific procedure. On the other hand, the longer the follow-up the greater the risk of contamination by extraneous variables. In this study, differences between short and long term follow-up were most apparent in cognitive function after bilateral amygdalotomy. There were no such differences in behavioural checklist results.

This is interesting, in comparison with the study by Horowitz et al. (1970). In this, emphasis was laid on the disruptive reaction immediately following surgery, and the subsequent turbulent phase of readjustment, with the implication that it is only after this that the time effect of surgery can be detected.

It is particularly important in long term follow-up to utilise techniques based on age norms, in order to take maturational changes into account.

In the present study where significant improvement was noted, this was shown to be over and above the effects of maturation.

(ii) In clinical studies, such as the present one, the difficulties in identifying psychological concepts are highlighted; similarly, there is the problem of establishing the relationship between overt behaviour, mood, attitudes and consistency of behaviour over time and in different situations./

situations. At the outset of the study it was decided to accept that personality questionnaires measure what their manuals say they measure. It was therefore particularly interesting to find that clinical observations of disinhibition following lesions in central brain areas were reflected in the change in personality profile obtained from administration of a questionnaire. Of the three main operative groups, the greatest change on Cattell's Sixteen Personality Factor Questionnaire occurred following lesions in central brain areas. The pattern of change, with decreased anxiety and increased extraversion, is in keeping with findings following thalamic lesions, reported by Orchinik (1962) and Jurko and Andy (1973). These authors used projective techniques, not personality questionnaires. Similar changes have been found following frontal lobe surgery (Partridge, 1950). This can be explained in terms of the rich network of connecting fibres between thalamic and frontal regions of the brain.

A similar pattern was observed in daily self-ratings of mood using a line-marking scale. Following central lesions, changes tended to indicate an increased sense of well-being, while changes following amygdalotomy and temporal lobectomy were in a negative direction. The latter was anticipated from the reports of postoperative depression by a number of authors (Falconer and Taylor, 1970; Horowitz et al., 1970). The former can then be explained at a neuro-anatomical level by considering the amygdala as a mesial temporal structure. It is of interest to point out that following amygdalotomy, the pattern of change on Cattell's Sixteen Personality Factor Questionnaire was closer to that of the central lesion group, with, for example, decrease in shyness. The temporal lobectomy group showed very little change postoperatively in/

in personality profile. Shute (1973) has suggested that similar effects following thalamotomy and amygdalotomy can be explained at a biochemical level in terms of their involvement in cholinergic activity. It is difficult to know how far apparent differences in psychological function in this study should be explained at a biochemical and neuro-anatomical level, rather than being interpreted as an artefact, since the numbers in each group are small, and variance within the group large.

(iii) One of the most unexpected findings of the study was the improvement in non-surgical cases. Three possible explanations will be considered. One is that patients are likely to be referred for a radical therapeutic approach, at a peak of disturbance, at a time of crisis. This may represent a turning point and thereafter all patients appear better, whether or not they have undergone surgery. This explanation is plausible when it is remembered that one of the non-surgical control groups includes referred cases in whom no surgery was carried out, and cases in whom neurosurgery was deferred. Initial referral is likely to be at the point of worst behaviour. Thereafter staff attitudes may also change in the knowledge that "something is going to be done", in an attempt to solve the problem. This explanation does not account for the improvement noted in some areas of behaviour in the sample of institutionalised subnormal patients with epilepsy, who formed the control group used in evaluating the results of the Hargreaves Nursing Rating Scale. These patients were not referred for surgery.

A second possible explanation is simply in terms of inconsistency in behaviour. It has been shown that within each group there are wide variations in change scores, as well as in numbers improving or not improving./

improving. Such fluctuation in behaviour within groups might well be obscuring the effect of any specific neurosurgical procedure. This explanation could apply to comparisons with both non-surgical groups mentioned above.

Rodin (1968) found that retesting of intellectual level in patients with epilepsy revealed greater variability in performance than anticipated from known test retest reliability. The variability within groups in the present study has been repeatedly noted in assessment of aspects of both cognitive function and behavioural disturbance. With the small numbers within each of the main operative groups, such variability has tended to preclude the demonstration of any effects on psychological function which could be specifically attributed to any one procedure. This explanation accounts for <u>change</u> in the assessment of individuals, more readily than it accounts for the <u>improvement</u> in a number of areas of disturbed behaviour in the non-surgical cases. Both the Adaptive Behaviour Scale and the Hargreaves Nursing Rating Scale were designed to measure disturbance. Hence a tendency to regress to the mean might be interpreted as more likely to result in a decrease in score for disturbed behaviour, since the bulk of patients on whom both these scales were standardised obtained zero or low scores.

This explanation might be put forward in terms of either patient or rater behaviour. This leads to a consideration of a third possible explanation. The measuring instruments may be unreliable in use with these raters and these groups of patients, i.e. the improvement in ratings may not reflect a true change in behaviour. If this is the explanation for the non-surgical group, it must also be applied in interpreting the findings in surgical cases. There was greater awareness/

awareness of the need to take inter-rater reliability into account, than of the need to account for lack of reliability in the same rater over time.

The validity of parental judgments has been questioned in a number of instances. Parents have sometimes failed to endorse any of the items of disturbed behaviour on the checklist, while the child in question indulges in extremely destructive, antisocial behaviour, at that very point in time. In one case, parents completed the scale independently, in the presence of the psychologist. The number of items endorsed placed their son as more disturbed than 90% of an equivalent population. Three months after an exploratory procedure only, the parents again completed the checklist. This time no items of violent, antisocial nor self-abusive behaviour were endorsed. If the validity of checklists completed by parents and others is in doubt, there is every reason to be even more suspicious of opinions expressed in answer to questions asked by the clinician, at follow-up outpatient clinic.

In the past, accounts of abnormally aggressive behaviour by relatives have been regarded as sufficient indication for neurosurgical intervention. In this study, the same behaviour checklist is completed by parents as by raters observing the patient in other environments (school, occupational therapy, hospital). If their checklists show no disturbance, the first question asked is in terms of inter-rater reliability, as discussed above, between parents and other raters. However, if these scores are reflecting a true difference in behaviour, then the second question must be asked. If a change of environment is sufficient to suppress, inhibit or to avoid eliciting/

eliciting disturbed behaviour, is neurosurgery justified?

In the case above, failure to demonstrate any disturbed behaviour during a month's inpatient assessment in the special unit, was part of the rationale for carrying out an exploratory procedure only. "Post-operative" ratings in the special unit also showed little sign of disturbance and, as indicated above, this was reflected in parental ratings three months later. A plausible explanation, in terms of the therapeutic effect of a spell away from home, is refuted by the knowledge that there had been a number of periods of hospitalisation prior to referral for surgery. The same checklist completed by nursing staff based on the patient's behaviour during one of these earlier spells confirmed the disturbance reported by the parents.

An alternative explanation can be made in terms of expectations of surgery. This may affect observers as indicated above and patients. Both this and another patient in whom the neurosurgical procedure was only an exploratory one, rated themselves as better "postoperatively" than any other group of cases.

If there are dangers of biassed results in psychological research through "experimenter effects" (Rosenthal, 1966), there are even greater dangers in a study of this type. The use of rating scales and checklists unfortunately always leaves room for some subjective interpretation. This is considered less of a risk where ongoing behaviour is observed directly, as in the method of five minute periods of observation described in this study. However, such a method cannot account adequately for changes in the behaviour of others towards the patient under observation. Such changes may be reciprocated by a change in the patient's response. In any case, this method was applicable/

applicable to only a limited number of the patients in whom assessment of behaviour was required, nor was it guaranteed to provide all the relevant information. Some data of importance to the patient's way of life were impossible to collect without resorting to methods entailing the risk of more subjective judgments. Major changes, such as a patient becoming hospitalised or becoming employed, are objective criteria. However, in this study it was considered necessary to try to monitor changes in behaviour which might not be great enough to be reflected in any major change in life style.

(iv) The types of rating scale and checklist used are different from the Social Adjustment Scale used by Taylor and Falconer (1968). However, the analysis carried out of institutionalisation and occupation can be directly compared. Although not significant in the Taylor and Falconer study, there is a trend to improvement (more patients at home than in hospital postoperatively). Using the formula provided by these authors on the data in Table XXXIII(a) in the present study, there is a significant deterioration (more patients hospitalised postoperatively). Taylor and Falconer's group showed significant improvement in occupational level, whereas in the present study there was improvement, but not significant. This calculation was again based on Taylor and Falconer's method, which gives a X^2 value based on relative numbers improving/declining, but ignoring total sample size. In the present study, evaluation of change has tended to consider the proportion of cases not changing, although a similar method to this one was used occasionally.

(v) Initially, the results presented from this study of amygdalotomy appear to be very discrepant from other published studies. With the small/

small numbers available, and with the variability within the groups, amygdalotomy has not been demonstrated statistically to be more effective in modifying most aspects of disturbed behaviour, than is "no treatment" nor than a procedure aimed at relief of epilepsy.

It is important to avoid drawing the simple conclusion from these results that "amygdalotomy doesn't work." After all, this study has shown that amygdalotomy can be followed by significant decreases in a wide range of disturbed behaviour, in some individuals. This finding is similar to that reported in many published studies (Narabayashi et al., 1963; Heimburger et al., 1966; Sweet et al., 1969; Vaernet and Madsen, 1970; Balasubramaniam and Kanaka, 1973). A number of these studies have the advantage of larger numbers, but tend to give only very sparse details of assessments made. The major advantage of the present study was that it was able to ask a further question: "Do these changes distinguish this group from patients undergoing other neurosurgical procedures, and from patients in whom there was no neurosurgical procedure?"

It was found that other neurosurgical procedures (including explorations only) produced significant decrease in level of disturbed behaviour in some cases. These changes could not be explained by maturational factors alone. When group mean scores were considered, rather than individual change, it appeared on inspection that surgery was more effective than no surgery in reducing level of violent and destructive behaviour. When subjected to statistical analysis, the differences failed to reach a significant level.

The pattern of results obtained from checklists and rating scales did demonstrate greater change after amygdalotomy, than after no surgery/

surgery, in one area - rebellious, unco-operative behaviour. No attempt has been made to explain this finding in terms of known or hypothesised functions of the amygdala. The postoperative changes in observed behaviour were not reflected in any change in the pattern of responses to a self-report questionnaire covering aspects of hostility. Postoperative level remains as abnormally high as it was pre-operatively.

The results of this study have indicated how justified Ursin and others have been in their criticism of lack of controls in studies evaluating the effects of neurosurgical procedures on behaviour. There can no longer be complacency about the reliability of the measuring instruments used. Hence interpretation of individual post-treatment change is much more difficult. Ursin and others engaged in experimental work with brain lesions in animals, have scoffed at attempts to identify specific behavioural effects with the global approach used in human studies of behaviour pre- and post-operatively.

Criticisms of morality, not methods, have come from many non-physiologically orientated psychologists who dismiss the whole concept of modifying behavioural patterns through neurosurgical intervention as (a) impossible and (b) immoral. This has become a very emotive issue. An ardent opponent says of psychosurgery, "At best it blunts the individual and at worst it destroys all his higher capacities" (Breggin, 1972). The present study provides no evidence to support this.

In this study, the term "aggression" has been used to indicate <u>disturbed</u> behaviour, and yet obviously, certain forms of aggressive behaviour in society are regarded as extremely effective rather than being/

being maladaptive habits.

The neurosurgeon's criterion for accepting a patient for surgery is based on a judgment - the judgment that the pattern of aggressive behaviour is detrimental to the patient's wellbeing, not that it is detrimental to society. The aim of surgical intervention has been to render the individual more effective rather than more manageable.

The ethical question is not seen to arise where aggressive, maladaptive behaviour is seen as one aspect of an epileptic disturbance.

(vi.a) The relationship between epilepsy and behaviour disturbance has been investigated in various ways in this study. The possibility of an association between postoperative improvement in behaviour and improved seizure control was investigated. In a number of individual patients, less disturbed behaviour postoperatively coincided with improved seizure control. However, decrease in disturbed behaviour was not restricted to the group with a reduction in seizure frequency. This is different from the finding of Taylor and Falconer (1968) that "relief of epilepsy was almost essential to improved social adjustment."

The type of aggressive behaviour pattern associated with epilepsy can also be considered in relation to results obtained from lesions in brain areas known to have particularly low thresholds for epileptic activity. If the amygdala has an inhibitory or facilitatory role in mediating aggressive behaviour, then lesions in the amygdala might be expected to alter patterns of impulsive physical attack or of destructive behaviour. It is difficult to explain the apparently specific reduction in rebellious, unco-operative behaviour in terms of this type of functioning. Rebellious, stubborn behaviour might be assumed to be a more complex, learned manipulative behaviour pattern/

pattern, far removed from anything which has been identified in animals as a behavioural response to stimulation or other activation of structures involved in the mediation of aggressive responses. However, before dismissing this point, a further unexpected finding will be mentioned. Stimulation of the amygdala in man was found to produce restless, destructive behaviour. This could be related to the "flight—fight" pattern in animals (Kaada, 1967) and to the "march of temporal lobe epilepsy" in man (Stevens, 1957). More dramatically, stimulation of the amygdala produced sudden, verbally aggressive behaviour, with swearing and verbal threats. These again were more complex, learned patterns than the simple physical attack or destructive behaviour.

(vi. b) The stimulation study was the most direct method by which the epilepsy-aggression-limbic relationship was studied.

The study of behavioural responses occurring during stimulation of localised areas of the brain has been criticised in that such responses are artefacts which do not yield valid results (Mark et al., 1972) and even more so when these studies are carried out in the operating theatre (Sem-Jacobsen, 1970). In monkeys aggressive responses were elicited only in the appropriate social situation (Rosvold et al., 1954). An operating theatre might be regarded as an inappropriate situation for the expression of emotional reactions.

The only aim of stimulation at surgery was in physiological localisation prior to coagulation. In all of these patients the main or one of the main presenting complaints was a pattern of abnormal aggressive behaviour and hence we were particularly interested in the aggressive responses which were elicited. In our one-stage bilateral/

bilateral operations it may not even be possible to specify exactly that responses obtained during stimulation of the second side definitely are such or no more than the delayed effect of stimulation and coagulation of the contralateral amygdala. Further objection to describing the functions of the amygdala in terms of results obtained during stimulation and coagulation at surgery is that we were not able to allow sufficient intervals between one stimulation and another or between stimulation and coagulation to extrapolate adequately the after-effects of one stimulation from the direct effects of the next. Again studies using chronic implanted electrodes, those of Sweet et al (1969), King (1960) and Sem-Jacobsen (1970), with intervals of 5 to 10 minutes between stimulations, do enable more exact analysis to be made. However, with these patients it was not considered a necessary part of the pre-operative investigations to have implanted electrodes and it was not considered justifiable to use these merely for research purposes.

Many studies mention that negative emotions can be elicited by electrical stimulation (Heath and Mickle, 1960; Gloor, 1960) but few describe in detail the behaviour elicited. One exception to this is the work of Sweet et al. (1969) who do provide detailed description of telemetric stimulation in several patients. Comparison of our results with these published studies indicates that we were eliciting certain responses at surgery which had not been recorded previously.

(vi.c) The stimulation study was the nearest approach to a direct examination of the <u>mechanisms</u> of aggression. They have been distinguished by Vowles (1970) from the <u>functions</u> of aggression for the individual.

In individual clinical case assessment of patients there was discussion/

discussion of the role of aggressive responses in the individual's behavioural repertoire. The question often cropped up of whether the aggressive responses seemed to be triggered by some internal neurophysiological disturbance or represented a learned pattern of manipulative behaviour. Reference was made to situational factors specific to the patient which precipitated violent, destructive or abusive responses. To develop methods of subjecting alternative hypotheses of the causation and function of the abnormal aggressive behaviour to the test has proved beyond the scope of the present study. A preliminary investigation of one aspect of this, related to persistence and tolerance of frustration, has been undertaken.

(vii) So far, it has been possible to demonstrate, in a group of student nurses, a meaningful relationship between persistence as a rateable characteristic and performance on one of three experimental tasks. The relationship between frustration tolerance and persistence remains to be elucidated. The validity and reliability of the two other experimental situations designed to measure the effect of failure and the effect of pressure on performance, has not been demonstrated. None of the methods is reliable enough at present, for use as a measure of intra-individual change. Already, however, interesting comparisons can be made between groups, in performance on the task measuring persistence (Mirror Drawing). It was found that the students spent a significantly longer time on the task than did the group of patients with epilepsy. A meaningful interpretation of this would require to have the patient group matched with a control group for age, sex and intellectual level. A further comparison would then be useful with a group of non-epileptic psychiatric patients. A more easily/

easily interpreted finding was that within the patient group tested so far, a few patients in whom no epileptic phenomena were demonstrated, were least persistent. On none of the three experimental measures was the performance of patients with evidence of temporal lobe involvement different from patients with non-temporal lobe epilepsy.

(viii) These findings from performance in a standard situation reflect the results obtained from personality questionnaires and behaviour checklists. Four aspects of these will be mentioned. The first is the confirmation of the whole sample of patients as deviant. From the clinical description of psychiatric status presented at the beginning of the study, this was certainly expected. The high proportion of disturbed cases in this series was similar to that reported by Falconer and Taylor (1970) in a series of one hundred cases of temporal lobe epilepsy selected for neurosurgical treatment. In general, patients with epilepsy have been shown to have a higher risk of psychiatric disturbance (Tizard, 1962; Stevens, 1966; Graham and Rutter, 1968; Mignone et al., 1970).

The next question raised is whether the behavioural and personality disturbance represents a specific syndrome, whether an "epileptic personality" can be identified. A questionnaire covering aspects of hostility was selected for inclusion in the assessment schedule, because of the indication that aggressiveness was one area in which this group seemed likely to be particularly deviant. This was confirmed by the group obtaining a significantly higher mean score than the groups of psychiatric patients on whom the questionnaire was originally standardised. However, since this questionnaire has come under/

under criticism recently (Philip, 1973) no more detailed analysis in terms of pattern or direction of hostility was carried out. On the other questionnaire (16 P.F.) the personality profile for the group was more like the profiles of groups with physical disabilities, than any of the psychiatric groups. There was wide variability of disturbance on all areas of the Adaptive Behaviour Scale. Furthermore, the pattern of change on this scale did not relate to change in seizure pattern, as already discussed. Graham and Rutter (1968) found, in a school population, that the type of disturbance shown by the neuro-epileptic group did not differentiate them from the neurotic anti-social (non-neurological) children in the group.

In the same study, behavioural disturbance tended to be specifically associated with the presence of psychomotor seizures. Rodin (1968) has suggested that it may be useful to try to delineate the characteristics of a subgroup within the temporal lobe epilepsy category who showed behaviour or personality abnormality. However, the present study represented a further attempt to find out whether cases with <u>any</u> evidence of temporal lobe involvement could be identified as different, in personality or behaviour, from patients with epilepsy in whom there was no evidence of temporal lobe involvement. This system of classification was found difficult to implement, for, as has been pointed out by others, the distinction between temporal lobe and non-temporal lobe epilepsy is much less clearcut in patients than in textbooks. No differences were found between the two groups on check-lists, nor on questionnaire (nor on time spent on a frustrating task). This discussion of the relationship between type of epilepsy, personality and behaviour, has dealt with the third point.

Finally/

Finally, an explanation is suggested of the findings in the few patients referred with a provisional diagnosis of epilepsy, but in whom no epileptic phenomena were demonstrated. These few cases were found more deviant than the other groups in the study - they were more hostile, less persistent and obtained higher scores for disturbed behaviour on a number of areas of the Adaptive Behaviour Scale. It is suggested that these patients fit the stereotype of the "epileptic personality" and referral for investigation was made on the basis of this, rather than of any neurological indication of epileptic disturbance. Alternatively, it might be that in these patients who are so extremely difficult to manage, conventional therapeutic approaches have failed. The referring psychiatrist may be unwilling to contemplate "psychosurgery." If the behaviour disturbance can be diagnosed as an "epileptic equivalent", then neurosurgical intervention is a much more acceptable therapeutic approach.

Where numbers are small, explanations of results are speculative. The nature of the present study has inevitably involved analysis of data on fewer cases, and less perfectly matched controls than is desirable. The demands of research design must come second to clinical responsibility for the patient. The researcher feels more secure in discussing results where numbers are adequate. The psychologist can be more confident about the measurement of differences between individuals, or groups, than the measurement of intra-individual change over time.

(ix) It is therefore satisfying to turn to a consideration of one of the main findings of the retrospective study, in which samples were much larger, and some of the variables under consideration more readily/

readily classified. The results obtained confirmed the consensus (Rodin, 1968) that early age of onset of epilepsy is associated with poorer performance on tests of intellectual level. At a theoretical level this can be explained by Piercy's hypothesis (1964) that the infant brain is more equipotential for intellectual development than is the adult brain, for the sustaining of intellectual skills.

(X.a) Neither neurologists nor neurosurgeons will be surprised by the relative lack of serious long-term decline in general intellectual level postoperatively; while psychologists, working outwith the neurological field, despite decades of research indicating similar results, remain apprehensive, some fearing that no patient undergoing brain surgery can emerge with intellect intact.

Because of the small numbers involved, specific effects on cognitive function of particular neurosurgical procedures have been difficult to demonstrate statistically.

(X.b) The study has shown that there was a tendency to decline noted postoperatively on most aspects of cognitive function. This decline was insignificant in most cases. It tended to persist after lesions in central brain areas, whereas it reversed in the longer term follow-up after amygdalotomy. Andersen (1972) detected a deficit in learning in a group of patients a year after amygdalotomy. She used both verbal and non-verbal material and attributed the deficit to the registration phase of learning. In the present study, no deficit was detected at follow-up of a few cases more than three months after amygdalotomy, either on verbal learning, or on a delayed recall task, or on a test of short-term memory for non-verbal material. There was evidence of transient postoperative impairment in certain aspects of memory function./

function.

(X.c) Changes in verbal function, memory and learning were expected and noted following lobectomy of the dominant temporal lobe. However, our small numbers seemed unlikely to enable us to investigate specific aspects of this as fruitfully as has been done in other centres with much larger series of patients (Milner, Meyer, Blakemore and others). Nor were the numbers much larger for the two other main operative groups considered in detail. However, for these the existing body of knowledge is much smaller and hence it seemed of great importance to collect the maximum amount of data. No attempt was made to correlate exact lesion site within thalamus and adjacent structures, with change in cognitive function, as has been done by Jurko and Andy (1973).

(X.d) In reporting personality changes, the similarity of effects following central lesions, to those reported to follow frontal lobe lesions, was noted. The Porteus Maze Test has been claimed to measure foresight and planning capacity and to be sensitive to impairment in these abilities after frontal lesions. On the very limited amount of evidence available from this study, performance on the Porteus Maze Test appears to be more adversely affected than non-verbal reasoning, by central lesions. There was a drop in level of performance on a range of tests of cognitive function after placement of lesions in central brain areas. This might be explained in terms of a general slowing down, based on Hicks and Birren's (1970) hypothesised relationship between deterioration in basal ganglia structures and psychomotor slowing with age. If so, it should have been possible to confirm the postoperative decline in cognitive function, by finding a decline in psychomotor speed. An alternative hypothesis suggested that/

that increased impulsivity, disinhibition and increased extraversion were likely to be reflected in reduced delay in reacting to stimuli. Decrease in time taken to respond to Rorschach cards was reported by Orchinik (1962) following thalamotomy. Could this be demonstrated on a simple reaction time task? Although the surgical group as a whole showed a number of significant changes on a reaction time task, no consistent pattern of change was demonstrated by the cases with lesions in central brain areas. There were indications that reaction time was quicker immediately after amygdalotomy. This could be considered to have implications for the postulated role of the amygdala in attention and orientation.

(xi) The range of theoretical explanations suggested above, in relation to one task, brings to mind Zimet and Fishman's (1970) caveat: an apparently simple task cannot be assumed to measure one specific psychological function. What it measures must be demonstrated. This was one reason precipitating the development of the study, from simple reaction time, to include possible aspects of vigilance and distraction. This is a most important area of cognitive function, not only in considering the effect of neurosurgery, but also the epileptic process itself. Much further work remains to be done in the field broadly labelled "attention", currently under investigation in a number of units, including Oxford (Stores, 1973).

A further caveat in testing cognitive function comes from Williams (1973). She has indicated that the verbal learning task included in her Memory Scale was one of the tasks on which performance was prone to be influenced by so many factors that it could not be regarded as a valid test of learning.

The/

The difficulties in disentangling the effects of specific lesions on general intellectual level are partly attributable to the impossibility of isolating individual "psychological functions." Where a global measure, such as WAIS IQ is used, results are often reported to indicate decline in a specific aspect, but as showing no decline in general intellectual level. Conversely, a drop in IQ, which on inspection can be seen to occur as a result of decline on one particular subtest, is interpreted as a drop in general intellectual level. These are problems common to many avenues of psychometric testing. They tend to be highlighted when specific impairment is being investigated in terms of focal brain lesions.

The continued search for reliable methods of investigating psychological function, in individuals to whom normal base rates do not apply, has to be one object of further study in this field.

(xii) The trends demonstrated in this study can be confirmed only with collection of further data. Increase in rate of cases referred seems unlikely in view of the persisting reservations about neurosurgical intervention in this area. At the present rate of accumulation of data, a time scale of the order of twenty years would be required to collect adequate data. There has been an unexpected, but extremely welcome, degree of interest in the present study, especially in methods developed for evaluation of aggressive and other disturbed behaviour. This has come from those engaged in similar work around the world and has led to consideration of a co-operative study, using the same assessment methods in a number of different units where the same neurosurgical procedures are being carried out.

Thus, the present study is seen in the light of establishing a foundation/

foundation on which further work can be based. Topics which have emerged as particularly relevant are: improvement of methods of measuring intra-individual change in behaviour, the relationship between epilepsy, behaviour and limbic structures, and the whole field of cognitive function in epilepsy, with emphasis on the processes involved in attention and memory.

CONCLUSIONS

CONCLUSIONS

The following conclusions can be drawn from the main study:

(1) It has not been possible to demonstrate statistically significant differences between the pattern of postoperative change in cognitive function, occurring after stereotactic lesions in central brain areas, stereotactic amygdalotomy and unilateral temporal lobectomy, although some trends have been apparent. These indicate a tendency to transient decline, of significant degree in a few cases. This was more notable and persistent following unilateral or bilateral central lesions, while decline immediately following bilateral amygdalotomy was reversed in the longer term. Reaction time was quicker immediately after amygdalotomy. The expected impairment of verbal function and memory followed left temporal lobectomy.

(2) The study has demonstrated different patterns of change in personality profile, with least change following temporal lobectomy and most apparent, a decrease in anxiety and an increase in extraversion and in sense of well-being following central lesions. There were no significant changes in levels of hostility assessed by questionnaire. Daily self-ratings, using a line-marking scale, indicated that patients tended to feel worse following amygdalotomy and temporal lobectomy. The greatest improvement was felt by two cases in whom the operative procedure was an exploratory one only.

(3) The study has demonstrated, through behavioural observations, rating scales and checklists, significant decreases in hostile, aggressive behaviour in some cases following amygdalotomy. Apart from behaviour described as rebellious and stubborn, this study has failed to/

to distinguish change following amygdalotomy from change in a control group (consisting of these cases prior to surgery, and non-surgical cases). There was wide variation in the pattern of change within each group. In addition, other neurosurgical procedures (including explorations only) produced significant decrease in level of disturbed behaviour in some cases. These changes are not explained by maturational factors alone. Where mean scores were considered, it appeared on inspection that surgery was more effective than no surgery in reducing level of violent and destructive behaviour, but when subjected to statistical analysis, the differences failed to reach a significant level.

The secondary aspects of the study have:

(4) confirmed this sample of patients with epilepsy as deviant in intellectual level, personality and behaviour,

(5) confirmed a number of previous studies, showing that patients with epilepsy in whom there is evidence of temporal lobe involvement do not differ from patients with no such evidence, in cognitive function, personality or behaviour. Results from this study have indicated that a very small number of cases in whom no epileptic phenomena were demonstrated, were more disturbed, as assessed by questionnaire and behavioural assessment,

(6) failed to demonstrate that patients with epilepsy selected for surgery differ from those not selected in personality, or behaviour or in general intellectual level, when age of onset of epilepsy is taken into account.

The above points answer the six questions asked at the outset of the study. In addition it was found that:

(7)/

(7) Stimulation of the amygdala produced aggressive responses and destructive behaviour in several cases, as well as other emotional reactions, and a range of responses of interest in their resemblance to seizure patterns.

(8) While in individual cases, improved behaviour coincided with relief of seizures, consideration of the group as a whole failed to demonstrate an association between decrease in seizure frequency and decrease in disturbed behaviour. In contrast to the marked post-operative improvement in disturbed behaviour obtained on rating scales and checklists is the relative lack of change in level of occupational activity and need for hospitalisation. In a number of cases in all three main operative groups, there was improved seizure control and less disturbed behaviour. Nevertheless, it might be said that these were not reflected in any major change in life style.

(9) Patients with epilepsy are often described as having a low level of tolerance of frustration. The present study included preliminary attempts to develop methods of measuring this. It was found that members of a group of student nurses could be meaningfully ranked by each other as more, or less, persistent. This was found to correlate with time spent on a frustrating task (mirror drawing). Patients as a whole spent a shorter time than students. The few patients in whom no epileptic phenomena were demonstrated spent the shortest time. This reflected the pattern obtained on a number of techniques of assessment of personality and behaviour.

(10) Finally, it is important to comment on the wide gap between theoretical concepts of brain-behaviour relationships and their demonstration in patients. This is less true of aspects of cognitive function/

function than it is of emotional behaviour and long-standing personality characteristics. The main achievement of this study lies not so much in conclusive findings, as in its observations. These can now provide a foundation for long-term extensive investigation of behaviour before and after neurosurgical intervention, and of psychological function in epilepsy.

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APPENDIX 1

Appendix 1 — A STUDY OF FRUSTRATION TOLERANCE

INTRODUCTION

In order to evaluate certain of the measures being developed for use in the assessment of patients with epilepsy in whom surgical treatment was being considered, a small study was carried out on a control group of 25 student nurses.

The main aim of the study was to investigate differences in individuals' behaviour in certain standard situations, empirically considered to be mildly stressful or frustrating, and to see how far these differences reflected personality characteristics, moods and attitudes, and how reliable such differences were over time.

Neurologists have described the person labelled as having an "epileptic personality" as demonstrating a low threshold for frustration tolerance and over-reaction to stress (Hill, 1957, 1959). Some of the patients with epilepsy treated surgically in Edinburgh were being described after operation as "less impulsive" and "more able to tolerate frustration." It seemed important to attempt to evaluate this aspect of behaviour. Certain scores on the personality questionnaires in use are related to this area - for example Factor C, in Cattell's Personality Factor Questionnaire. A low score on Factor C is obtained by the person who is easily annoyed by things and people and who has a low level in frustration tolerance. However, Factor C is "the most general pathological contributor, being found in neurotics, psychotics, alcoholics, drug addicts" whereas the implication is of a more specific characteristic in the epileptic patients described.

Factor/

Factor E on Cattell's 16 P.F., and the Hostility and Direction of Hostility Questionnaire provide measures of extrapunitiveness. Where this reflects tendency to act out then it is also related to response to stressful situations.

This aspect of behaviour is also covered by the Adaptive Behaviour Scale, a checklist completed by those familiar with the patient's behaviour. There is one item on reaction to criticism and one on reaction when thwarted. These are part of the 'psychological disturbances' scale. The reliability of any individual item in a test tends to be lower than that of the whole scale, and test authors frequently warn of the dangers of making assumptions about reliability of individual items.

Many of the patients with epilepsy were too dull or too disturbed to complete personality questionnaires. It was not convenient to have all patients rated on the Adaptive Behaviour Scale. It was decided to supplement the assessment by observing patient behaviour in situations which were judged to be frustrating and which were appropriate for the wide age range, intellectual ability and level of psychological functioning, which the patient group involved.

An extensive search of the literature for methods which could be replicated did not provide the answer. Methods used in studies of aggression in American college students, such as administering electric shocks (Geen et al., 1968) were considered unethical for patients.

Another method was used by Barker et al. (1941) in which toys with which children had been allowed to play, were cut off from them, behind a wire or glass screen. The amount of aggressive behaviour ensuing/

ensuing could then be measured. This type of technique would be applicable to only a minority of the patients in the current study. It was considered undesirable to place patients in situations where the dependent variable was aggressive, destructive behaviour. Many of these patients are dangerously violent or self-mutilative and hence the deliberate manipulation of a situation to produce aggressive behaviour is not acceptable.

It was hypothesised that, given the opportunity, the individual whose level of tolerance of frustration is low would terminate rapidly situations in which normal channels to goal achievement are blocked, and that he would persist for much longer on a task if he was receiving feedback indicating that he was succeeding than if feedback indicated failure, irrespective of the actual standard of performance. His response to the situation could be explained either in terms of failure to inhibit inappropriate responses, or as a tendency to seek an alternative response, which will reduce the level of frustration. Consider individual A who, when he is failing, stops trying much sooner than individual B. He may do so because he is unable to inhibit the response of destroying the equipment, walking out, or swearing at the experimenter. B may feel the same at the same point in time, but he may inhibit the impulse and continue on the given task.

Alternatively, A may have a lowered threshold for frustration. C may not be distressed by a situation which A finds extremely stressful. C may become frustrated by the situation, but at a later point in time or with increased levels of stress in the situation. When an individual begins to find the level of stress intolerable, he may/

may pick an effective solution - that of opting out. If this solution is not available, a crisis is likely - either physiological or behavioural.

To assume level of neurophysiological arousal as the only critical variable in the situation, would be naïve. How long someone persists is likely to be related to previous experience in situations requiring persistence. Thus for the individual whose previous persistence led to success, persistence is a more likely outcome in the experimental situation than it is for the individual whose experience is of failure to achieve a goal, even after persisting.

A central theme of one major theory in this field (Dollard et al., 1939) is the role of frustration in the development of patterns of aggressive behaviour.

It may also be useful to consider behaviour in situations in which goals are not blocked, but in which pressure is imposed on the individual. Where there are two criteria of success (as for example speed and accuracy) the individual must decide how to balance these two to achieve his optimal level. If pressure is exerted to alter his decision in some way, how is the individual's performance affected?

If failure to tolerate frustration is conceptualised in terms of over-reaction, then it might be expected that the individual who opts out of the frustrating situation at an early stage, will over-react to situations in which he is under pressure. The individual who gives up impulsively because of failure to inhibit, and the individual who gives up because maximum level of frustration tolerance has been reached, might both be expected to over-react to pressure, i.e. pressure will affect performance adversely. Pressure may also affect adversely/

adversely the performance of the individual who has been very persistent in frustrating situations and where he is told he is failing. Those who are very persistent, but react dramatically to a mild degree of pressure, might be a group with a high level of anxiety.

It is possible to ignore feedback about level of performance. The individual who does so, is also less likely to be affected by being pressurised to increase speed or accuracy.

Having considered possible interpretations of individual differences in behaviour in a range of situations, the techniques described below were developed for use with a group of patients with epilepsy. It then became important to find out what was being measured by these situations and how well it was being measured. This was investigated by seeing how far behaviour of a group of student nurses in these standard situations reflected personality characteristics, mood, attitudes, as measured by questionnaire techniques and as rated by other people. The student nurses were relatively homogeneous in age and level of effective functioning and all female. In such a group, acquainted for six months, it may be possible to obtain a consensus of opinion of how far certain individuals possess certain characteristics, relative to the other group members.

METHOD

There were four parts to the study.

1. Ratings - Six adjectives or adjectival phrases were selected which were thought to be related to behaviour in the standard situations, described below; these were then used to head numbered sheets as follows: (a) most anxious

(b)/

(b) most able to tolerate frustration

(c) most persistent

(d) most irritable

(e) most self-critical

(f) most critical of others

Lists of the members of the class of student nurses to be asked to co-operate in the study were then drawn up.

Each student nurse present in the class was given one class list and six headed sheets. The students were told that this was the first of several studies on which their co-operation was being sought. This first study was of personality - to find whether class members agreed on how far other class members possessed certain characteristics. If they wished to co-operate they should rate class members (including themselves) on the characteristic indicated at the top of each sheet. They should write the names of fellow class members, in the appropriate order. For example, the name of the person they considered most anxious should be written beside number 1, the next most anxious as number 2, and so on. They were instructed to work as quickly as possible, spending only 5-10 minutes on each characteristic.

A few class members objected on principle and opted out of the task. Several of the nurses felt that there were some class members whom they did not know well enough to rate in a meaningful way. Some found one or more of the characteristics particularly difficult to rate and these were omitted.

An unforeseen complication arose in that five students had only just joined the class and were not known to the others. These five did know each other to a limited extent and separate ratings were carried/

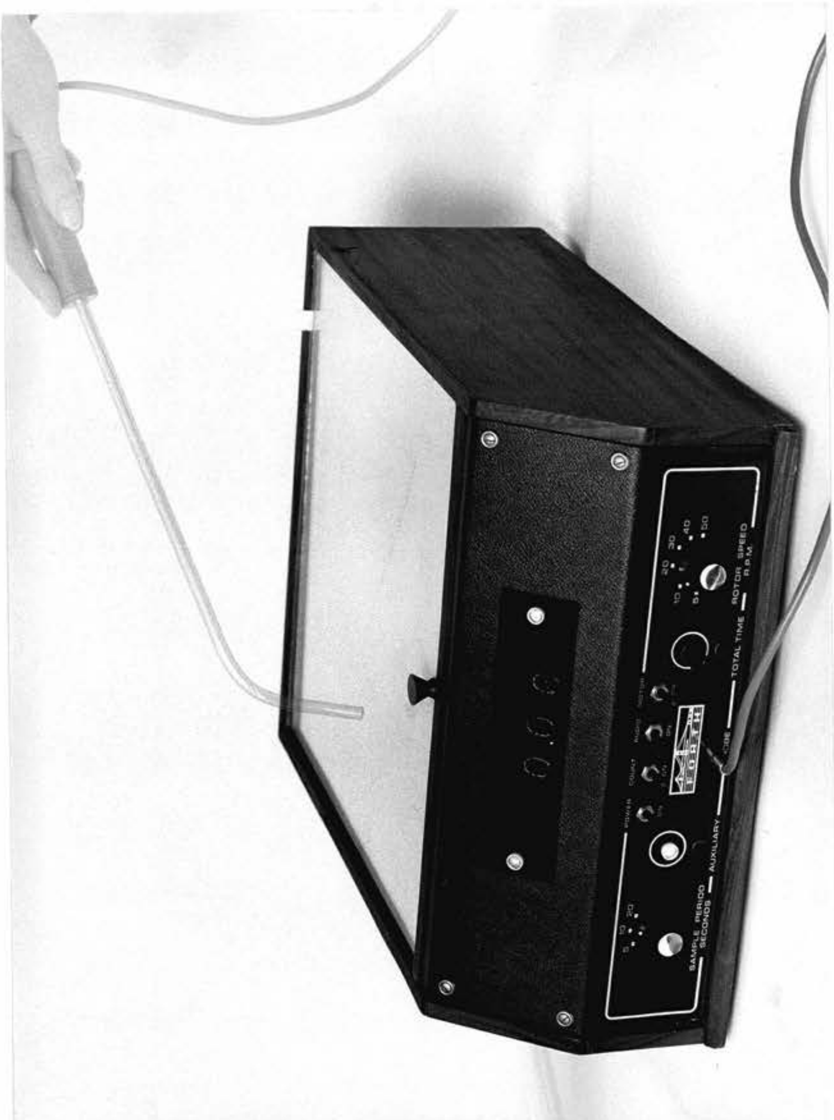

Fig. 26 Pursuit Rotor

carried out of each other, for this group.

2. At the same session at which ratings were completed, the nurses were also asked to complete "The Hostility and Direction of Hostility Questionnaire." They were asked to put their names on this, as it would be useful to see how their scores on questionnaire compared with how they were rated by others in the class. This questionnaire measures current attitudes and distinguishes between hostility directed outwards (characterised by criticising others and acting out) and hostility directed inwards, which is characterised by self-criticism and guilt.

3. The same group of students were then asked if they would participate in another study, related to eye-hand co-ordination. They were told that this was being investigated in a group of patients undergoing surgical treatment of epilepsy and that it was important to know how well a group of students did on tasks measuring eye-hand co-ordination. Thus the students were not informed of the real purpose of the study or of the relationship between this and the first part of the study. Twenty-two of the 25 students participated in this part of the study.

During the testing session, students were asked to complete a copy of the Visual Analogue Scale (a method of measurement of mood, devised by Zealley and Aitken (1969)). For some this was completed at the outset and repeated at the end of testing.

<u>Pursuit Rotor</u>

The first task was a tracking task. The aparatus used, <u>a pursuit rotor</u>, is shown, and described in Fig. 26. The subject is seated in such a position that she does not see the digital display of/

of her time on target. As used in this study, the subject (a) has a number of 10 second trial runs on a circular pattern at speeds from 5-45 rpm, with the tone generator switched on to give auditory feedback. (b) Then, the speed is fixed at 12 rpm and the tone generator switched off. The pattern is changed to one in which the moving target describes a square. The subject is given the following instructions: "From now on you will not have the buzzer to tell you when you are managing to keep the tip of the probe on the light. Instead I will tell you how you are getting on. I get a reading every 10 seconds which tells me how much of the time you are on the light, so if I say you got 9 that is extremely good. It means that you were on the light for 9 out of the 10 seconds. If your score is only 1 then that's not so good. We are going to try you first with your right (or preferred) hand and then with your left hand on this design. Then we will change to another design and try that first with your left and then with your right hand. Each time I want you to let me know when you wish to stop. So, we start now using this hand. I tell you how you are getting on. You tell me when you want to stop. O.K?"

The subject then begins to track the light and every 10 seconds she is given a reading. However, this is in fact a false series of readings. Her true score is also recorded. If she is still persisting at the end of the 13th and 23rd trials (peak false readings), she is again instructed, "Remember you can stop whenever you like. Just let me know." At the 30th trial, she is told that she must now change over, or she will be too fatigued to cope with subsequent parts of the study.

(c)/

Fig.27 Mirror Drawing

(c) The procedure is then repeated using the non-preferred hand, on the square design. The instructions about stopping whenever she wants are given before the 1st, 14th and 24th trials as before. This time false readings, indicating deteriorating performance are given, providing a similar pattern of plateaux, but with declines instead of increases.

When the subject indicates her desire to stop (d) the design is changed to a star pattern and the procedure repeated, using first the non-preferred hand on which false success readings are now given, and finally (e) a series of false failure readings, with the preferred hand.

The number of 10 second trials attempted under different conditions could then be compared.

The second task was Mirror Drawing. This provides a situation in which established habits of eye-hand co-ordination fail to produce the required result. The apparatus is shown in Fig. 27.

The subject is seated in such a position that when her hand is inserted into the box she cannot see it, but can see the mirror image. She is instructed as follows: "You have to draw a line round the figures, between the double outline. You will probably find it's quite difficult to do. It's a bit like what you were doing on the Pursuit Rotor, in that you decide how long you want to spend on it. You can try as many different designs as you like, and do as many of each as you want. You get a score for your best attempt at each design. You can move the sheet around, as long as you still see your hand only in the mirror. Start now and let me know when you want to stop."

As/

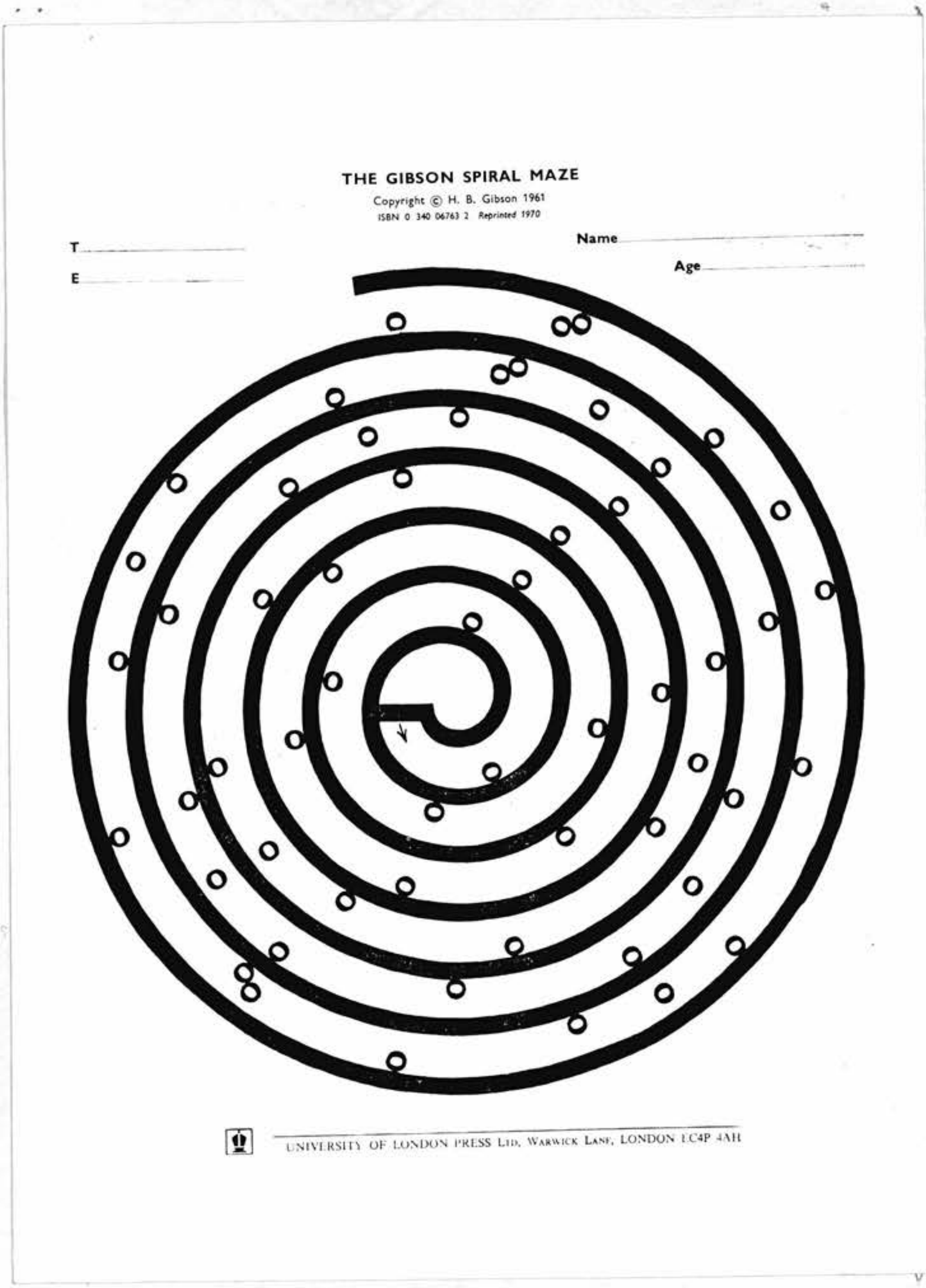

Fig.28 Gibson Spiral Maze.

As soon as the subject indicates the desire to stop, the time is noted. If she is still persisting after 15 minutes, she is asked to stop.

She then proceeds to the final task, The Gibson Spiral Maze. Fig. 28 is a copy of the Maze card used. There are four trials, all using the non-preferred hand (except in subjects where co-ordination was so poor as to make this task possible only using the preferred hand). The subject is required to trace a path round the image, avoiding the black lines and the circles. On the first trial she is instructed to "go as quickly as possible. Start now and let me know when you have finished." Timing is done as unobtrusively as possible during this trial, and the experimenter ignores the subject's performance, by reading or looking out of the window, etc. Time at which the maze is completed is noted. The subject is then told that she has done well but that on the next trial she must try to increase speed, but still be as careful as possible. Timing is made obvious. The experimenter sits over the subject, stopwatch in hand. The subject is told, "Wait till I tell you to start. Right. Start." Every 15 seconds the subject is stressed, according to the instructions in the Gibson Spiral Maze Manual. Comments are made every 15 seconds in the following order:

(1) "You have to go as quickly as possible."

(2) "Hurry, hurry."

(3) "Quick, quick."

(4) "You aren't going quickly enough."

These are repeated if subject is still not finished. The time of completion is again noted.

The/

The subject is told that she was a bit quicker that time, but that she made more errors. She is instructed to have another go, "keeping up your speed, but without any mistakes at all this time!"

Timing is again done obviously on this third trial, and stress is again imposed at 15 second intervals, with the following comments:

(1) "You have to be as careful as possible."

(2) "Careful, careful."

(3) "Take care, take care."

(4) "You're not going straight enough."

The time of completion is again noted.

The subject is then told that she is to have a last trial and that this time she is to try to "keep up both things. Go as quickly as you can, but as carefully. Start now and tell me when you have finished." As on the first trial, the stopwatch is used unobtrusively and the experimenter ignores the subject's performance.

Subjects were then asked to describe how they felt doing each task.

4. They were then asked if they would be willing to repeat these three tests in 3-4 weeks' time (reasons of reliability were explained briefly). All agreed to do so. Unfortunately a number of practical obstacles, including an outbreak of influenza and emergency duty due to a strike of ancillary hospital workers, resulted in only 10 of the nurses being available for retesting at the prescribed time. The above procedure was repeated for these 10 subjects.

RESULTS

The first step was analysis of the ratings, to find the degree of concordance. By a process of eliminating raters and rated on whom data/

TABLE XXXV : Group Ratings - Kendall Coefficient of Concordance (W)

Variable	No. rated	No. of raters	No. prorated	W	Level of Significance
1. Anxiety	20	9	3	.279	$p < .001$
2. Frustration Tolerance	19	9	10	.11	$p > .05$
3. Irritability	19	6	3	.34	$p < .001$
4. Persistence	20	8	5	.27	$p < .001$
5. Self-critical	20	6	4	.19	$p > .05$
6. Critical of others	20	5	1	.57	$p < .001$

data were least complete, a final table was drawn up (Table XXXV). The column headed "Number prorated" indicates the extent to which incomplete data were included in each of the six variables.

Such prorated items were treated as tied ranks in the subsequent analysis. It was considered that the most appropriate method of handling the data was to calculate the Kendall coefficient of concordance for each of the six variables (Seigal, 1956). The results yielded are shown in Table XXXVI. The question of repeating the analysis based on different combinations of raters was considered, in order to establish whether a significant level of concordance could be established for "frustration tolerance" and "self-critical", but it was decided that this would alter the initial questions being asked.

If a significant degree of concordance has been found, Kendall suggests a method of obtaining the best estimate of the true rankings of the individuals comprising the sample (Seigal, 1956). This is provided by the order of the various sums of ranks obtained by the individuals. This was used for the four variables for which significant values of the coefficient of concordance had been obtained (Anxiety, Irritability, Persistence, Critical of others).

For the additional small group of five nurses the same analysis was carried out. This failed to yield a significant level of concordance on any of the six variables.

For the main group the rank order obtained as described above, provided data on four of the six variables, which could be treated in the same way as data from the other aspects of the study.

Next the student nurses were ranked according to scores obtained on "The Hostility and Direction of Hostility Questionnaire" (HDHQ), from/

from highest level of hostility to lowest. The normative data available for this questionnaire cannot be applied to those under 20 years of age. This may mean that the questionnaire is measuring a different aspect of psychological functioning at younger ages. However, it still seems appropriate to consider individual differences in raw scores. Total score as well as scores indicating direction of hostility (extrapunitive and intropunitive) can be used.

The Visual Analogue Scales were measured, and subjects ranked for each of the five scales. Next the results from the standard situations were considered. For the pursuit rotor, interest was in the difference between number of trials when succeeding and when failing rather than in total length of time. An index was calculated as follows:

a = number of trials using preferred hand and given false success readings

b = number of trials using non-preferred hand and given false failure readings

c = number of trials using non-preferred hand and given false success readings

d = number of trials using preferred hand and given false failure readings.

$$\text{Index of effect of failing} = \frac{(a + c) - (b + d)}{a + b + c + d}$$

Subjects were ranked from highest negative to highest positive index, i.e. from those who persisted much longer when failing to those who persisted longer when succeeding.

For Mirror Drawing, subjects were ranked from 1-22, based on the time/

time spent on the task. Those who persisted for the whole 15 minutes were rated first (with a tied rank of 3), down to those who spent shortest time on the task.

From the Gibson Spiral Maze an index of the effect of pressure on performance was calculated. This was based on the time score and the error score for each trial. Gibson (1965) provides details of the method for scoring errors. The effect of pressure on speed was calculated as follows; a, b, c, d refer to time scores on each trial 1-4:

$$\text{Index of effect of pressure on speed} = \frac{(a_1 + d_1) - (b_1 + c_1)}{a_1 + b_1 + c_1 + d_1}$$

The effect of pressure was thought likely to increase the number of errors (whereas it reduces the speed). The effect of pressure on accuracy could then be expressed as an index

$$= \frac{(b_2 + c_2) - (a_2 + d_2)}{a_2 + b_2 + c_2 + d_2}$$ (where a_2 b_2 c_2 d_2 refer to error scores on each of the trials 1-4)

It was desired to obtain an overall index of the effect of stress or pressure on performance. This was done by taking the mean of the indices for speed and errors. The expected effect of pressure was to decrease time (increase speed) and to increase errors. In a minority of cases there was a decrease in time and errors. It seemed important to evaluate these differently from cases showing the same amount of change in error score, but in the opposite direction. To do this, algebraic sign was taken into account in calculating the mean index of effect of pressure. This was not entirely satisfactory, however, as it might equate those whose performance was not altered by pressure with those whose change in time score was cancelled out by change in error/

TABLE XXXVI : Correlation between Variables (Spearman rho) in Frustration Tolerance Study

	Ratings				Experimental Measures			H.D.H.Q.			VAS-Line-Marking Scale				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Persistence	-														
2. Irritability	.6*	-													
3. Anxiety	.22	.06	-												
4. Critical of others	-.07	.78*	-.33	-											
5. Pursuit Rotor	.2	.2	-.08	.21	-										
6. Mirror Drawing	.43*	.05	.45*	.12	.3	-									
7. Gibson Spiral Maze	-.29	.03	-.06	-.17	-.39*	-.12	-								
8. HDHQ (Total)	.39	-.1	.2	.11	-.04	-.17	.1	-							
9. Extrapunitive	-.07	.07	-.11	.29	-.06	.26	-.06	.88*	-						
10. Intropunitive	-.44	-.45	-.34	-.52*	.23	.34	.03	.64*	.23	-					
11. V.A.S. Depressed	-.34	0	.42	-.16	-.08	-.11	.41*	.42	.32	.3	-				
12. Tired	-.1	-.7	.02	-.48*	.25	-.27	.11*	-.26	-.26	.17	-.27	-			
13. Ill	-.23	-.27	.23	-.26	-.74*	.14	.4	.2	.06	.38	.22	.17	-		
14. Badly Treated	-.16	.03	-.23	.26	-.36	-.15	.23	.17	.01	.36	.32	-.08	.5*	-	
15. Tense	.23	.19	-.46*	.12	-.17	-.05	-.16	.25	.25	.10	.22	-.37	.2	.13	-

* p < .05

error score. It is important to note that by using an index to provide a measure of relative change, no assumptions are made that one unit of time (second) was equal to the error. Subjects were ranked according to the obtained index, from first, least affected by stress to last, most affected by stress.

By now the subjects were ranked on all 15 variables in the study - though information was incomplete insofar as ratings were not available for all students on whom other tests had been carried out. The next step was to investigate relationships between the variables. This was done by calculating the coefficient of correlation (Spearman rho) between each pair of variables. Table XXXVI contains these data.

For the three experimental measures, it was also useful to consider the distribution of scores obtained, since one aim of the study was to compare the performance of a control group with that of a group of patients with epilepsy. These data are shown in Table XXXVII. The limited test/retest data available for 10 cases are given in Table XXXVIII.

In terms of validating the three experimental measures (standard situations), none of the ratings (anxiety, persistence, irritability and critical of others) were related to the indices obtained on the pursuit rotor or on the Gibson Spiral Maze. Nor were scores on the personality questionnaire related to any of the experimental measures. Two of the four ratings were significantly correlated with Mirror Drawing. Those who were rated as most persistent and those rated as most anxious tended to spend longest on Mirror Drawing. However, the correlation coefficient between these two sets of ratings (i.e. persistence/

persistence and anxiety) is +.22 which is not a significant one.

The only one of the validating measures which was significantly related to the index of effect of failure on the pursuit rotor, was one of the Visual Analogue Scales - "Well - Ill." It appeared that those who rated themselves as feeling most well were most likely to give up when failing. On the other hand, it was those who felt most well who were least affected by pressure imposed on the Gibson Spiral Maze, as were those who felt most depressed. The correlation between these two Visual Analogue Scales (ill and depressed) was only .22. The three other Visual Analogue Scales - tired, tense, badly treated - were not related to any of the experimental measures.

The relationship between performance in the three experimental situations is interesting. There is a slight positive correlation between the index of effect of failure on the pursuit rotor and the time spent on Mirror Drawing, i.e. those who were more persistent when told they were failing on the pursuit rotor, tended to persist longer on Mirror Drawing. Length of time spent on Mirror Drawing is not related to the index of effect of pressure (Gibson Spiral Maze). Those who persisted longest when told they were failing on the pursuit rotor were most affected by pressure on the Gibson Spiral Maze.

One aim of the study was to look at the range of scores obtained by a normal group. The performance of the group of patients with epilepsy could then be compared with this normal group. As yet, differences between the two groups cannot be interpreted, since this study does not yield the necessary information about performance in individuals matched for age and intellectual level with the epilepsy patients. In the present study, the indications are that performance in/

TABLE XXXVII : Experimental Measures - Distribution of Student Nurses Scores (N = 22)

	Possible Range	Mean	S.D.
1. Pursuit Rotor (Index of Effect of Failure)	From -1 to +1	+.11	.18
2. Mirror Drawing (Time spent on task)	From 0 to 15 minutes	10.1 minutes	3.26
3. Gibson Spiral Maze (Index of effect of pressure)	From -1 to +1	+.21	.11

TABLE XXXVIII : Test-Retest Reliability (10 cases only)

Test	Test-Retest (Spearman rho) Correlation
Pursuit Rotor	.3
Mirror Drawing	.57*
Spiral Maze	.22
HDHQ	.83*
V.A.S. 1. Depression	.04
2. Tired	.48
3. Ill	.48*
4. Badly Treated	.69*
5. Tense	.77*

* $p < .05$

in a group of student nurses on the Mirror Drawing task differs from that of a group of patients with epilepsy, whereas performance in the other two standard situations does not differ to the same extent. It was important to establish whether any differences existed prior to considering a more difficult study - that of matching the patients with epilepsy, on relevant variables.

The study also provided information on the relationship between the variables, included for purposes of validation. Returning to Table XXXVI, it is of interest to note that there is a statistically significant negative correlation between ratings of "most critical of others" and intropunitive scores on the Hostility and Direction of Hostility Questionnaire. There is also a significant negative correlation between ratings of anxiety and self-rating (line-marking scale) of tension. The Visual Analogue Scale was designed to provide a measure of change within an individual, rather than as a method of evaluating inter-individual differences. No claim can be made that such scales measure the same thing in all individuals. Furthermore, how near an extreme the individual considers himself to be, may be unrelated to how far he appears to others to possess a given characteristic. Within the Visual Analogue Scales, those who marked a more extreme position for feeling ill also felt more badly treated by others.

In some aspects this study has been a rather negative one - in that relatively few relationships were found which indicated that the three experimental situations were providing a measure of the variables to which they had empirically appeared to be related. Perhaps it was rather optimistic to expect these measures to be very sensitive/

sensitive at such an early stage in their development - and they would have to be sensitive to detect differences in a selected occupational group. Nurses might be regarded as highly selected in terms of their ability to cope with stress.

An increasing body of evidence provides links between emotional state with physiological and neurophysiological variables - such as Galvanic Skin Response, forearm blood flow, EEG alpha rhythms, as exemplified in the Lader and Wing studies (1966). In the light of these, it must be argued that this study of tolerance of frustrating situations and reaction to stress, would have more usefully used neurophysiological measures instead of ratings and questionnaires, as the validating measures, or even as the dependent variables.
It was not considered feasible to use neurophysiological measures as dependent variables for the patient sample. The difficulties of obtaining co-operation in disturbed patients to attempt the actual tasks were great enough, and the extra time and co-operation required to obtain accurate physiological measures was considered impractical. Such measures could have been utilised in the control study, but less conveniently, than obtaining ratings and questionnaire responses. Moreover, ratings of characteristic ways of behaving by other group members had face validity. Standardised questionnaires provided an external criterion of validity.

The three chosen experimental situations all involve visual perception and eye-hand co-ordination. This degree of continuity across situations was considered desirable. The equipment itself, the movements involved and the level of difficulty are different in the three tasks. The tasks were designed for use with disturbed patients/

patients, not with the control group. Many of the patients quickly became bored in any situation, and past experience had indicated that the chosen number of trials, under different sets of conditions, should be the minimum required for accuracy. Visuo-motor tasks were chosen, partly from the observation that in some of the patients it was much easier to obtain co-operation on tasks requiring manipulation of apparatus. With overactive youngsters, any office equipment (typewriter, telephone, etc.) could retain their attention for much longer periods than standard items of psychological testing. At the other end of the spectrum, for the more sophisticated patients, these tasks were a plausible extension to some of the other tests completed, and were accepted as relevant. Other tasks reported in the literature (such as holding one foot for a length of time in very cold water) would have been rather more suspect.

Baldwin (1960) has stated that psychological investigations, in which subjects are deceived about the real aim of the study and about the variables being measured, are better left undone. This argument may be acceptable in the experimental field. In the clinical field, it may happen that methods do not exist for exploring adequately the variable in question directly and with the subject's knowledge. Patients undergoing medical treatment are rarely in possession of the aims of particular investigations. In the current study, student nurses who were asked to volunteer, were given the same information as patients, i.e. that the experimental tasks were tests of eye-hand co-ordination, and of the difference in performance using preferred and non-preferred hands.

Despite the limitations of this preliminary study, work in this area/

area should continue. "Frustration" and "aggression" are rather over-used words today. Many of the shortcomings of the present study can be attributed to the dearth of objective evidence or testable hypotheses on which to found further study.

CONCLUSIONS

A group of female student nurses could meaningfully be ranked by the members of the group, as to how anxious, persistent, irritable and critical of others they were. How well they tolerated frustration and how self critical they were could not be established by the rating method used. The ratings could be related to a limited extent to pattern of responses to a questionnaire covering aspects of hostility, and to self ratings of mood, using a line marking scale.

These variables were investigated to provide a basis for establishing the validity of other measures being developed to study frustration tolerance and response to stress. Three experimental situations had been designed. The first two, investigating response to failure and goal blocking, were slightly, but not significantly related. The third, looking at effects of pressure on performance, was found to be inversely related to the first measure. None of the three measures was related to score on the Hostility Questionnaire. Only one (Mirror Drawing) was found to be related to the group rating. Performance was related to how persistent and how anxious the subject was rated, in relation to other group members. The other two experimental measures were related to self-ratings (line-marking scale). On the first of these two measures (Pursuit Rotor), further investigation with different values of the independent variables would be of interest.

A/

A very limited investigation of test retest reliability indicates that of the three experimental measures, it is the one which is most valid in terms of persistence (Mirror Drawing) which is also the only reliable one. A fuller study of reliability is required.

This study indicates that in a group, relatively homogeneous in age, sex, intellectual status and level of effective functioning, the experimental measures designed to measure frustration tolerance and response to stress are not adequately sensitive.

It appears that level of frustration tolerance is difficult to evaluate both as personality characteristic and as a specific response to standard situations. Persistence is easier to evaluate by both methods, but the relationship between these two terms is not yet clear. Further development of the measures used in this study is worthwhile.

TABLE XXXIX: Individual Reaction Time Results; comparison of pre-&post-operative mean scores.

Pt's Initials	Short/ Long term.	Simple Reaction Time Right Hand pre	post	t	Left Hand pre	post	t	Vigilance pre	post	t
Central lesion group										
L.A.	Short	.27	.28	.09	.29	.31	.4			
	Long	.27	.22	2.09 $p<.05$	.29	.19	3.5 $p<.001$			
F.G.	Short	.28	.3	.4	.26	.25	.1	.38	.42	.3
J.D.	Short	.29	.26	1.5	.27	.29	1.4			
	Long	.34	.33	.6	.48	.41	1.1			
M.M.	Short	.47	.36	3.7 $p<.001$	.40	.43	.7			
	Long	.47	.22	13.01 $p<.001$	.40	.31	2.73 $p<.05$			
J.M.	Short	.15	.18	1.5	.29	.19	4.3 $p<.001$			
D.M.	Short	.19	.31	4.3 $p<.001$	.19	.37	2.7 $p<.05$	.34	.32	0.1
	Long	.19	.28	3.4 $p<.001$	.19	.25	2.5 $p<.05$			
D.P.	Short	.16	.16	.05	.18	.16	1.6	.26	.19	1.9
	2nd op. Short	.14	.16	1.0	.14	.15	1.0	.12	.22	4 $p<.001$
A.P.	Short	.18	.24	2.8 $p<.05$	.14	.15	.1	N.B. Pt. left-handed		
	2nd op. Short	.18	.18	.2	.14	.16	.5			
B.R.	Short	.20	[illegible]	.4	.2	.24	1.4	.32	.44	1.1
	Long							.32	.22	1.3
	Distraction-S							.32	.4	1.2
	" " Long							.34	.22	2.4 $p<.05$
Amygdalotomy group										
G.C.	Short	.73	.34	4.65 $p<.001$	.65	.33	4.04 $p<.001$			
	Long	.73	.33	6.3 $p<.001$	.65	.4	3.06 $p<.02$			
B.G.	Short	.39	.27	1.2	.29	.18	2.2 $p<.05$			
W.L.	Short	.16	.20	3.2 $p<.02$	.17	.21	4.6 $p<.001$			
E.M.	Short	.38	.48	.8	.5	.56	.3			
J.M.	Short	.18	.13	2.6 $p<.05$	.16	.16	.32			
Temporal lobectomy group										
J.C.	Long	.2	.15	7.5 $p<.001$	.17	.15	1.9			
J.D.	Short	.18	.3	5.1 $p<.001$	.18	.28	6 $p<.001$			
	Long				.18	.3	15 $p<.001$			
P.C.	Short	.19	.39	2.8 $p<.05$	.16	.29	4.2 $p<.001$			
J.M.D.	Long	.28	.29	0.5	.39	.41	0.6			
G.P.	Long	.62	.53	0.7	.49	.64	2.0			
J.S.	Short	.28	.22	3.6 $p<.02$	.37	.21	6.3 $p<.001$	.31	.26	2.4 $p<.01$
V.T.	Short	.32	.42	2.5 $p<.01$	.28	.4	2.6 $p<.01$	.4	.54	3.3 $p<.01$

APPENDIX 2

Copies of Rating Scales and Checklists

Adaptive Behaviour Scale Part II only

Question Booklet

Please use attached Answer Sheets.

INSTRUCTIONS FOR PART II—PLEASE READ CAREFULLY

The items in ~~the remaining part of~~ this scale ask you how frequently a given behavior occurs for the person being considered.

Look at the following example:

ATTACKS OTHERS PHYSICALLY

Check (√) "No" or "Yes" on the answer sheet. If "Yes," select *all* statements that are true of the person.

a. Scratches, pinches or slaps others
b. Bites others
c. Uses objects as weapons against others
d. Chokes others
e. Other:

If you have never seen the person attacking others physically, check (√) "No" on the answer sheet and move on to the next item. If the person has a tendency to attack others physically, check (√) "Yes" on the answer sheet and also check (√) *all* statements that are true of the person. Notice that there are two columns on the answer sheet for your check marks. They are "occasionally" and "frequently."

In EXAMPLE 3 on your ANSWER SHEET (PAGE 7), the person slaps others *frequently*, and he bites others *occasionally*. Therefore, the check marks (√) are placed in the appropriate columns (Occas. or Freq.) "Occasionally" signifies that behavior occurs once in a while or now and then, and "Frequently" signifies that the behavior occurs quite often or habitually

In the example above, the space labeled "Other" is used because the person throws objects at others frequently. The check mark (√) is also placed in the appropriate column on the answer sheet to indicate the frequency of such "Other" behavior. The behavior listed must be a specific example of the behavior problem stated in the question, but one not covered by the examples given.

Please continue your rating by proceeding on to Part II. Note that the instructions given above are slightly different from those used for Part I.

PLEASE BE SURE THAT EACH NUMBER OF THIS SCALE IS THE SAME AS THE PAGE NUMBER AT THE TOP OF EACH COLUMN OF YOUR ANSWER SHEET.

PART II

A. VIOLENT AND DESTRUCTIVE BEHAVIOR

(1) THREATENS OR DOES PHYSICAL VIOLENCE

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Uses threatening gestures
b. Indirectly causes injury to others
c. Spits on others
d. Pushes, scratches or pinches others
e. Pulls others' hair, ears, etc.
f. Bites others
g. Kicks, strikes or slaps others
h. Throws objects at others
i. Uses objects as weapons against others
j. Chokes others
k. Hurts animals
l. Other:

(2) DAMAGES PERSONAL PROPERTY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Rips, tears or chews own clothing
b. Soils own property
c. Deliberately tears up own magazines, books, or other possessions
d. Other:

(3) DAMAGES OTHERS' PROPERTY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Rips, tears, or chews others' clothing
b. Soils others' property
c. Deliberately tears up others' magazines, books, or personal possessions
d. Other:

(4) DAMAGES PUBLIC PROPERTY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Tears up magazines, books or other public property
b. Is overly rough with furniture (kicks, mutilates, knocks it down)
c. Breaks windows
d. Stuffs toilet with paper, towels or other solid objects that cause an overflow
e. Attempts to set fires
f. Other:

(5) HAS VIOLENT TEMPER OR TEMPER TANTRUMS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Cries and screams
b. Stamps feet, banging objects or slamming doors, etc.
c. Stamps feet, screaming and yelling
d. Throws self on floor, screaming and yelling
e. Other:

B. ANTI-SOCIAL BEHAVIOR

(6) TEASES OR GOSSIPS ABOUT OTHERS

Check "No" or "Yes," If "Yes," select *all* statements that are true of the person.

a. Gossips about others
b. Tells untrue or exaggerated stories about others
c. Teases others
d. Picks on others
e. Makes fun of others
f. Other:

(7) BOSSES AND MANIPULATES OTHERS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Tries to tell others what to do
b. Demands service from others
c. Pushes others around
d. Causes fights among other people
e. Manipulates others to get them in trouble
f. Other:

(8) DISRUPTS OTHERS' ACTIVITIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Is always in the way
b. Interferes with others' activities, e.g., blocking passage, upsetting wheelchairs, etc.
c. Upsets others' work
d. Knocks around articles that others are working with, e.g., puzzles, cards games, etc.
e. Snatches things out of other people's hands
f. Other:

(9) IS INCONSIDERATE OF OTHERS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Keeps temperature in public areas uncomfortable for others, e.g., opens or closes window, changes thermostat
b. Turns TV, radio or phonograph on too loudly
c. Makes loud noises while others are reading
d. Talks too loudly
e. Sprawls over furniture or space needed by others
f. Other:

(10) SHOWS DISRESPECT FOR OTHERS' PROPERTY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Does not return things that were borrowed
b. Uses others' property without permission
c. Loses other people's belongings
d. Damages others' property
e. Does not recognize the difference between his own and others' property
f. Other:

(11) USES PROFANE OR HOSTILE LANGUAGE

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Uses hostile language, e.g., "stupid jerk," "dirty pig," etc.
b. Swears, curses, or uses obscene language
c. Yells or screams threats of violence
d. Verbally threatens others, suggesting physical violence
e. Other:

C. REBELLIOUS BEHAVIOR

(12) IGNORES REGULATIONS OR REGULAR ROUTINES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Has negative attitude toward rules but usually conforms
b. Has to be forced to go through waiting lines, e.g., lunch lines, ticket lines, etc.
c. Violates rules or regulations, e.g., eats in restricted areas, disobeys traffic signals, etc.
d. Refuses to participate in required activities, e.g., work, school, etc.
e. Other:

(13) RESISTS FOLLOWING INSTRUCTIONS, REQUESTS OR ORDERS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Gets upset if given a direct order
b. Plays deaf and does not follow instructions
c. Does not pay attention to instructions
d. Refuses to work on assigned subject
e. Hesitates for long periods before doing assigned tasks
f. Does the opposite of what was requested
g. Other:

(14) HAS IMPUDENT OR REBELLIOUS ATTITUDE TOWARD AUTHORITY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Resents persons in authority, e.g., teachers, group leaders, ward personnel, etc.
b. Is hostile toward people in authority
c. Mocks people in authority
d. Says that he can fire people in authority
e. Says relative will come to kill or harm persons in authority
f. Other:

(15) IS ABSENT FROM, OR LATE FOR THE PROPER ASSIGNMENTS OR PLACES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Is late to required places or activities
b. Fails to return to places where he is supposed to be after leaving, e.g., going to toilet, running an errand, etc.
c. Leaves place of required activity without permission, e.g., work, class, etc.
d. Is absent from routine activities, e.g., work, class, etc.
e. Stays out late at night from home, hospital ward, dormitory, etc.
f. Other:

(16) RUNS AWAY OR ATTEMPTS TO RUN AWAY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Attempts to run away from hospital, home, or school ground
b. Runs away from group activities, e.g., picnics, school buses, etc.
c. Runs away from hospital, home, or school ground
d. Other:

(17) MISBEHAVES IN GROUP SETTINGS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Interrupts group discussion by talking about unrelated topics
b. Disrupts games by refusing to follow rules
c. Disrupts group activities by making loud noises or by acting up
d. Does not stay in seat during lesson period, lunch period, or other group sessions
e. Other:

D. UNTRUSTWORTHY BEHAVIOR

(18) TAKES OTHERS' PROPERTY WITHOUT PERMISSION

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Has been suspected of stealing
b. Takes others' belongings if not kept in place or locked
c. Takes others' belongings from pockets, purses, drawers, etc.
d. Takes others' belongings by opening or breaking locks
e. Other

(19) LIES OR CHEATS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Twists the truth to own advantage
b. Cheats in games, tests, assignments, etc.
c. Lies about situations
d. Lies about self
e. Lies about others
f. Other:

E. WITHDRAWAL

(20) IS PROFOUNDLY WITHDRAWN AND INACTIVE

Having a low level of physical activity: Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Sits or stands in one position for a long period of time
b. Does nothing but sit and watch others
c. Falls asleep in a chair
d. Lies on the floor all day
e. Does not seem to react to anything
e. Other:

REMEMBER, RECORD YOUR RESPONSES ON THE ANSWER SHEETS

(21) IS WITHDRAWN BUT ACTIVE

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Seems unaware of surroundings
b. Is difficult to reach or contact
c. Is apathetic and unresponsive in feeling
d. Has a blank stare
e. Has a fixed expression
f. Other:

(22) IS WITHDRAWN OR SHY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Is timid and shy in social situations
b. Hides face in group situations, e.g., parties, informal gatherings, etc.
c. Does not mix well with others
d. Always prefers to be alone
e. Other:

F. STEREOTYPED BEHAVIOR AND ODD MANNERISMS

(23) HAS STEREOTYPED BEHAVIORS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Drums fingers
b. Taps feet continually
c. Has hands constantly in motion
d. Slaps, scratches, or rubs self continually
e. Waves or shakes parts of the body repeatedly
f. Moves or rolls head back and forth
g. Rocks body back and forth
h. Paces the floor
i. Other:

(24) HAS PECULIAR POSTURE OR ODD MANNERISMS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Holds head tilted
b. Sits with knees under chin
c. Walks on tiptoes
d. Lies on floor with feet up in the air
e. Walks with fingers in ears or with hands on head
f. Other:

G. INAPPROPRIATE INTERPERSONAL MANNERS

(25) HAS INAPPROPRIATE INTERPERSONAL MANNERS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Talks too close to people's faces
b. Blows on people's faces
c. Burps at others
d. Kisses or licks others
e. Hugs or squeezes others
f. Touches people inappropriately
g. Hangs on to others and does not let go
h. Other:

H. UNACCEPTABLE VOCAL HABITS

(26) HAS DISTURBING VOCAL OR SPEECH HABITS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Giggles hysterically
b. Talks loudly or yells at others
c. Talks to self loudly
d. Laughs inappropriately
e. Makes growling, humming, or other unpleasant noises
f. Repeats a word or phrase over and over
g. Mimics others' speech
h. Other:

I. UNACCEPTABLE OR ECCENTRIC HABITS

(27) HAS STRANGE AND UNACCEPTABLE HABITS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Smells everything
b. Inappropriately stuffs things in pockets, shirts, dresses or shoes
c. Pulls threads out of own clothing
d. Constantly plays with things he is wearing, e.g., shoe strings, buttons, etc.
e. Saves and wears unusual articles, e.g., safety pins, bottle caps, etc.
f. Hoards things, including foods
g. Plays with spit
h. Plays with feces or urine
i. Other:

(28) HAS UNACCEPTABLE ORAL HABITS

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Drools constantly
- **b.** Grinds teeth audibly
- **c.** Spits on the floor
- **d.** Bites fingernails constantly
- **e.** Chews or sucks fingers or other parts of the body
- **f.** Chews or sucks clothing or other inedibles
- **g.** Eats inedibles
- **h.** Drinks from toilet stool
- **i.** Puts everything in mouth
- **j.** Other:

(29) REMOVES OR TEARS OFF OWN CLOTHING

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Tears off buttons or zippers
- **b.** Inappropriately removes shoes or socks
- **c.** Undresses at the wrong times
- **d.** Takes off all clothing while on the toilet
- **e.** Tears off own clothing
- **f.** Refuses to wear clothing
- **g.** Other:

(30) HAS OTHER ECCENTRIC HABITS AND TENDENCIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Is overly particular about places to sit or sleep
- **b.** Constantly stands in a favorite spot, e.g., by window, by door, etc.
- **c.** Sits by anything that vibrates
- **d.** Is afraid to climb stairs or to go down stairs
- **e.** Does not want to be touched
- **f.** Screams if touched
- **g.** Other:

J. SELF-ABUSIVE BEHAVIOR

(31) DOES PHYSICAL VIOLENCE TO SELF

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Bites or cuts self
- **b.** Slaps or strikes self
- **c.** Bangs head or other parts of the body against objects
- **d.** Pulls own hair, ears, etc.
- **e.** Scratches or picks self causing injury
- **f.** Soils and smears self
- **g.** Purposely provokes abuse from others
- **h.** Picks at any sores he might have
- **i.** Pokes objects in own ears, eyes, nose, or mouth
- **j.** Other:

K. HYPERACTIVE TENDENCIES

(32) HAS HYPERACTIVE TENDENCIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Is constantly talking
- **b.** Will not sit still for any length of time
- **c.** Frequently runs or jumps around the room or hall
- **d.** Is constantly moving
- **e.** Other:

L. SEXUALLY ABERRANT BEHAVIOR

(33) ENGAGES IN INAPPROPRIATE MASTURBATION

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Has attempted to masturbate openly
- **b.** Masturbates in front of others
- **c.** Masturbates in group
- **d.** Other:

(34) EXPOSES THE BODY IMPROPERLY

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

- **a.** Returns from toilet undressed
- **b.** Stands in public places with pants down
- **c.** Exposes body excessively during activities, e.g., playing, dancing, sitting, etc.
- **d.** Undresses in public places, or in front of lighted windows
- **e.** Other:

(35) HAS HOMOSEXUAL TENDENCIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Is sexually attracted to members of the same sex
b. Has approached others and attempted homosexual acts
c. Has engaged in homosexual activity
d. Other:

(36) HAS HETEROSEXUAL BEHAVIOR THAT IS SOCIALLY UNACCEPTABLE

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Is overly seductive in appearance or actions
b. Hugs or caresses too intensely in public
c. Needs constant watching when around opposite sex
d. Lifts or unbuttons others' clothing to touch intimately
e. Has sexual relations in public places
f. Is promiscuous
g. Has attempted rape
h. Has raped others
i. Other:

M. PSYCHOLOGIAL DISTURBANCES

(37) TENDS TO OVER-ESTIMATE OWN ABILITIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Does not recognize his own limitations
b. Has too high an opinion of self
c. Talks about future plans that are unrealistic
d. Other:

(38) REACTS POORLY TO CRITICISM

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Does not talk when corrected
b. Withdraws or pouts when criticized
c. Becomes upset when criticized
d. Screams and cries when corrected
e. Other:

(39) REACTS POORLY TO FRUSTRATION

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Blames own mistakes on others
b. Withdraws or pouts when thwarted
c. Becomes upset when thwarted
d. Throws temper tantrums when he does not get his own way
e. Other:

(40) DEMANDS EXCESSIVE ATTENTION OR PRAISE

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Wants constant praise
b. Is jealous of attention given to others
c. Demands constant reassurance
d. Acts silly to gain attention
e. Other:

(41) SEEMS TO FEEL PERSECUTED

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Complains of unfairness, even when equal shares or privileges have been given
b. Complains, "Nobody loves me"
c. Says, "Everybody picks on me"
d. Says, "People talk about me"
e. Says, "People are against me"
f. Acts suspicious of people
g. Other:

(42) HAS HYPOCHONDRIACAL TENDENCIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the person.

a. Complains about imaginary physical ailments
b. Pretends to be ill
c. Acts sick after illness is over
d. Other:

REMEMBER, RECORD YOUR RESPONSES ON THE ANSWER SHEETS

(43) HAS OTHER SIGNS OF EMOTIONAL INSTABILITIES

Check "No" or "Yes." If "Yes," select *all* statements that are true of the child.

a. Changes mood without apparent reason
b. Complains of bad dreams
c. Cries out while asleep
d. Cries for no apparent reason
e. Seems to have no emotional control
f. Vomits when upset
g. Appears insecure or frightened in daily activities
h. Talks about people or things that cause unrealistic fears
i. Talks about suicide
j. Has made an attempt at suicide
k. Other:

N. SUPPLEMENTARY INFORMATION

(44) USE OF MEDICATION

Check "No" or "Yes." If "Yes," select *all* statements that are true of the child.

a. Uses tranquilizers
b. Uses sedatives
c. Uses anticonvulsant drugs
d. Uses stimulants
e. Other:

REMEMBER, RECORD YOUR RESPONSES ON THE ANSWER SHEETS

NOTES ON THE USE OF BEHAVIOUR OBSERVATION RECORD SHEETS

Each sheet is designed to be used for two consecutive 5 minute periods of observation.

1. Ensure that names, date and time of day are entered on sheet.

2. During the first 5 minute period the 2 columns marked "0-5 min." are used. The first time any of the behaviours listed occurs, a tick is placed beside it in the "0-5 min." column. Any other behaviour not covered by items on the list should be noted in one of the spaces for "other" or the space at the bottom of the sheet.

3. At the end of 5 minutes, the rater should start using the 2 columns headed "5-10 min.", again ticking the appropriate behaviour the first time it occurs during the 5 minute spell.

4. The rater should then have a break of 5 minutes and start on a new sheet, being sure to complete name, date and time. If it is possible to observe for a one hour period, a total of 4 sheets would be completed.

5. Periods selected for observation depend on the availability of observers. Ideally 12 sheets should be completed daily. Suggested times are:

Mid morning	2 sheets
Mid afternoon	2 sheets
Lunchtime (e.g. 12 - 1 p.m.)	4 sheets
Evening	4 sheets

It is very important to avoid using only the quietest times on the ward to do the observations. Even if far fewer than the above suggested times are feasible at least some should be completed at times when there is most pressure in the ward.

PATIENT'S NAME...................... RATER'S NAME........................

DATE................ TIME.........................

		0-5 min.	5-10 min.
VOCALISATION	Speaks: spontaneous		
	reply		
	Threat(verbal)		
	Swear		
	Incoherent		
	Gives orders		
	Refuses "No"		
	Laughs		
	Other :-		
ACTIVITY	Walk		
	Run		
	Stand		
	Sit		
	Lie		
	Leave room		
	Other:-		
	Play with toy		
	Use equipment(e.g.pen, cutlery)		
	Manipulate fixtures (tap,key,door etc.)		
	Any co-operative activity(describe)		
	Other		

		0-5 min.	5-10 min.
AGGRESSION	Hit		
	Kick		
	Push, pull, hold		
	Snatch object		
	Chase		
	Threaten(gesture)		
	Other :-		
ORAL	Drinks		
	Eats		
	Mouths inedibles		
	Kisses		
	Other:-		
SEXUAL	Masturbates		
	Exposes self		
	Inappropriate contact: male		
	female		
	Other:-		
	Sleeping		
	Awake		
	Any other behaviour:-		

COMMENTS:-

HARGREAVES

(MINUS Pg 8)

Rater's Guide for the Nursing Rating Scale

The Nursing Rating Scale is designed for daily use by psychiatric nurses and technicians. Its purpose is to describe the current behaviour of acutely psychotic patients and other patients undergoing a relatively brief hospitalization. This manual contains guidelines for each of the 20 rating items on the Scale. These guidelines will help you to determine the kinds of behaviour which should be given low, moderate, or high ratings.

3

The first 15 items concern depression, anger, anxiety, thought disorder, and interpersonal behaviour. For these items a zero rating means the particular behaviour is definitely not present, while 1-3 is the "low" range, 4-6 "moderate", and 7-9 "high." For items 16 and 17, Motility and Talkativeness, ratings of 4-6 represent average functioning, while ratings either above or below this range represent deviations from average. Items 18 and 19 are ratings of "effective" functioning rather than pathology, and the scale is reversed so that the 0-3 range represents "poor" functioning, 4-6 "fair", and 7-9 "good" functioning.

Raters are usually too reluctant to give ratings indicating extreme pathology, thinking that this means the behaviour is "as bad as it can get." Each rater should expect to give a 9 rating several times a year for every item. If necessary, the rater should agree to adjust the guidelines to match the patient population typically seen on the ward, so that high ratings are frequently used For example, with a ward of 20 patients or more, there should be some patients every week who get high (7-9) ratings on some items.

Raters may use information reported to them by other staff members to supplement their own first-hand observation of the patient, but with certain limitations. The rater should use such information if it will raise his rating, but not if it will lower it. For example, a report about a brief, but more disturbed behaviour than the rater himself has observed may justify rating the patients one or two points higher than the rater's direct observations would indicate. On the other hand, a rater who saw intensely disturbed behaviour for a brief time should rate the degree of disturbance he saw, and not lower his rating because he hears reports that the patient was not as disturbed at other times. This unusual strategy is necessary because of the way in which psychopathology is expressed in behaviour A brief episode of symptomatic behaviour often indicates the degree of disturbance being experienced by the patient, or the extent to which he is vulnerable to such experience. Only when symptom-free periods extend to several days or weeks are we confident that the patient is regaining a stable equilibrium.

It should be remembered that the guidelines presented in this manual are just that, guidelines and not inflexible criteria. Note that many of the guidelines equate a brief, intense expression of a behaviour with less intense expression which occur more often or more steadily. For some items, several different types of behaviour are mentioned in the guidelines, any one of which would justify a rating at that level. The guidelines indicate the general intent of an item, and similar behaviours may be included even though they are not explicity mentioned in the manual.

Worthless, hopeless, guilty, suicidal, helpless

1-3: Low. Mentions these feelings once or twice during shift or only on direct questioning: patient need not refer to these feelings by name if the content of his talk clearly demonstrates them.
4-6: Mod. Volunteers or admits to these feelings in conversation.

7-9: High. A large proportion of his talk is about being unhappy, worthless, hopeless or guilty.

2. Sad face, slumped body, self-destructive

1-3: Low. Slowed movements, sad looking, sad voice, or occasional teary-eyed.

4-6: Mod. Persistent dejected air; occasional crying.

7-8: High. Steady, persistent, extremely sad posture and expression; crying; suicidal gesture.
9: High. Serious suicidal attempt.

3. Physical complaints

1-3: Low. Occasional complaints.

4-6: Mod. Frequent complaints about real body ills, or exaggerates bodily ills.

7-8: High. Frequent and obviously unrealistic complaints about bodily ills, talk suggests somatic delusions.
9: High Clear expression bodily delusions.

5. Grumpy, resentful, sarcastic, abusive

1-3: Low. Occasionally sarcastic, snappish, grumpy, demanding.

4-6: Mod. An angry outburst: outspoken, annoyed several times during the day, or persistently grumbling or sarcastic.

7-9: High. Verbally assaultive or abusive more than once during the day or a large proportion of his talk is intensely angry; the person who is target of anger need not be present.

6. Annoyed face, threatening posture, striking another

1-3: Low. Annoyed facial expression; sullen; brusque or abrupt in interpersonal contacts.

4-6: Mod. Occasional intense, glaring, threatening expression, or moderate angry expression throughout the shift; slamming around, kicking or banging objects; noisy but non-destructive.
7-8: High. Threatening expression for several hours; hits or grapples with another person; destroys property.
9: High. Serious destruction of property or physical attack on another.

7. Stubborn, verbally resistive, physically resistive

1-3: Low. Avoiding obligations; failure to live up to established contracts; mild stubborness; resistive though claims willingness.

4-6: Mod. Failure to follow orders; verbally resistive, or sullenly defiant.

7-9: High. Physically refusing to conform to staff requests; physically resistive.

9. Anxious talk, worries, talks fearfully

1-3: Low. Mentions being anxious once or twice during shift or only on direct questioning - does not volunteer anxious talk; patient need not refer to fear or anxiety by name if the content of what he says clearly demonstrates it.
4-6: Mod. Occasionally talks about these feelings; worries about little difficulties; fearfully asks for reassurance; volunteers anxious talk.

7-9: High. A large proportion of his talk is about being anxious, fearful, or worried; insists on anxious talk.

10. Anxious manner: tense, jumpy, panics readily

1-3: Low. Somewhat tense; occasionally appears anxious or fearful; shy; anxious quaver in voice.

4-6: Mod. Tortured expression or mild tremor; distinct muscular tension; occasional startled or fearful expression.

7-9: High. Continuously agitated, hand-wringing, fearfully hiding, startling, gross tremor.

11. Pacing or wandering

1-3: Low. Occasional restlessness.

4-6: Mod. Pacing or wandering part of the time.

7-9: High. Aimless wandering around ward all day, or pacing continuously back and forth in same area; very restless.

4 Depression: overall rating.

This is the place where the rater can utilise the previous depression items 1-3, plus other aspects of the patient's behaviour, to give an overall rating for depression. The detailed items will help to bring to mind the various ways depression can be expressed, but there may be other aspects of patient behaviour which indicate depression. In most cases, the overall rating will be in the same range as the higher of either the talk or manner item. But it might be lower if you think the particular talk or manner is a sham, or higher if you can point to other behaviour which indicates more intense depression, but does not fit specifically into "depressed talk" or "depressed manner."

.8. Anger: overall rating

Utilising items 4-6 plus other aspects of patient's behaviour. The guidelines and overall ratings under item 4 apply also to this item.

12. Anxiety: overall rating

Utilising items 7-9 plus other aspects of patient's behaviour. The guidelines on overall ratings under item 4 apply also to this item.

18. Teasing, breaking rules, anti-social behaviour

1-3: Low. Mild limit testing, teasing; needs only minimal verbal limits, e.g. "cut it out."

4-6: Mod. Requires explicit, firm controls verbally, and responds to them.

7-8: High. Requires physical controls; PRN tranquillizers for control.

9: High. Seclusion required at least once for control.

19. Aloofness: remains alone, withdraws, unapproachable

1-3: Low. Tends not to get involved with others; may simply wish to be by himself, but responds to others' approach.

4-6: Mod. Avoids involvement much of the time, or with selected people, e.g. by being aloof from staff but not from other patients; aloofness may be expressed primarily in passive withdrawal.

7-9: High. Actively avoids contact or involvement with everyone; does not answer, turns away, leaves the room; at high levels the patient must be exerting considerable effort to avoid being involved.

20 Preoccupation: persistent thinking activity which replaces or interferes with appropriate attention to persons and events in the here and now

1-3: Low. Stares off into space or daydreams part of the time, but has no difficulty attending when involved in an activity or in conversation.

4-6: Mod. Stares off into space when left alone but attends fairly well to conversation when approached; or generally participates in surrounding activities but "drifts off" or loses flow of conversation occasionally.

7-9: High. Stares off into space all the time; or if talking, is limited to one or a very few topics.

13. <u>Disordered talk: loose, rambling, incoherent conversation</u>

1-3: Low. Talk is a little hard to follow; rambles.

4-6: Mod. Talk is hard to follow; easily distracted, subject changes, loose associations; cannot get his ideas out, as if thoughts came too fast.

7-9: High. Occasionally emits completely incoherent sentences; unconnected talk with grammar all mixed up; very loose or tangential associations; severe blocking; frequently retracts statements or immediately contradicts himself.

14. <u>Delusional talk: odd ideas, delusions or hallucinations</u>

1-3: Low. Odd ideas, unclear statements; strange ideas which raise questions of delusions; ideas or interests not themselves delusional but closely related to former delusions.

4-6: Mod. Suffers from delusions but is not completely in their grip; may report hallucinations but doubts their reality.

7-9: High. Content of talk is at times clearly delusional; ideas of persecution, somatic delusions, delusions of grandeur and delusions of absolute guilt; misidentifying persons, places or things; reports hallucinations.

15 <u>Crazy manner: peculiarities, symbolic gestures, posturing</u>

1-3: Low. Minor peculiarities, eccentric behaviour which does not clearly indicate thought disorder; person seems "odd" but his non-verbal behaviour would not ordinarily cause him to be hospitalised or to be seen as crazy by the average person.

4-6: Mod. Non-verbal behaviour which clearly indicates thought disorder but does not dominate or severely disrupt his functioning: wears inappropriate clothes; collects or carries around small objects; moderately catatonic, very indecisive; occasional bizarre or symbolic gestures or posture.

7-9: High. Posturing; extreme catatonic rigidity; undressing; bizarre costuming; smearing; behaviour suggests hallucinations.

9: Clearly behaves as if hallucinating, even if only once.

16 Suspicion

1-3: Low. Some suspiciousness, but no sign of paranoid delusions.

4-6: Mod. Suspicious talk but no direct admission of delusions, glancing around suspiciously; refuses food without admitting suspiciousness of being poisoned

7-8: High. Verbalizes paranoid delusions occasionally, or if questioned.

9: High. Verbalizes paranoid delusions spontaneously.

17 Asks for help, demanding, clinging

1-3: Low. Seeks occasional reassurance by asking others to make small decisions for him, or by asking trivial questions.

4-6: Mod. Often asks for help or reassurance; asks others to make important decisions for him; continuous indirect asking for help.

7-9: High. Verbally demanding or physically clinging; continuous direct requests for help.

24. Activity: immobile, to average (4-6) to hyperactive. Ratings of 3 or 7 may be normal for some individuals and do not necessarily indicate pathology
0: Low. Completely immobilised, never moving unless staff insists.
1-3: Low. Severely retarded, frozen or catatonic. Noticeably slower than is average for most people.

4-6: Mod. Normal daily fluctuations in an average person's motility.

7-8: High. Enough activity that is noticeably greater than average for most people.

9: High. Manic excitement, nearly constant physical activity.

22 Talkativeness: mute to average (4-6) to constant chatter

0 Low. Mute; does not talk.
1-3: Low. Little talk; single word answers. Quiet; doesn't waste words; prefers not to initiate contacts.

4-6: Mod. Talks about as much as an average person.

7-8: High. Gregarious; likes to initiate contacts with others.

9: High. Constantly talking; unable to stop.

23
Effective contact with people: reality, honesty, warmth. Ineffective functioning - able to be discharged

1-3: Poor. Conversation, doing tasks, playing games, or just being with other people is characterized by aloofness, quarrelling, tension, coldness, unrealistic dependency.

4-7: Fair. Engagement is partial and sporadic; less aloofness, more realistic expression of feelings; difficulty being direct; awkward but trying.

7-9: Good. Is able to show through deeds and words some concern for other people; works, plays, talks with others successfully; is relatively direct; interpersonal frictions are resolved almost as well as the average nonpatient.

24 Effective general functioning. Poor, fair, and good ranges are determined by the patient's ability to perform the type of functions shown. Rate no higher than 3 if you feel the patient probably could not minimally care for himself all day alone

1-3: Poor. Feed self without assistance; keep his clothing appropriate without assistance; make his bed by himself; wash face, take shower without supervision; stay in an exercise group and follow the exercises; wash his clothes without help; remain in O.T.; stay with group on outings; be aware of the score in games played.
4-6: Fair. Groom himself appropriately; stay with tasks on the ward; participate effectively in O.T.; carry out cooking project with others; participate sensibly in activities planning meeting; handle building passes with another patient; initiate and plan a project in O.T. on his own.
7-9: Good. Function adequately in volunteer work; handle unaccompanied passes away from the hospital; successfully manage home visits; look sincerely for work or perform a job; plan realistically for discharge.

Nursing Rating Scale: Record Form

Patient's Name:

Recorded by:

No.:

Date:

Time:

19	16	13	10	7	4	1
0	0	0	0	0	0	0
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9

20	17	14	11	8	5	2
0	0	0	0	0	0	0
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9

	13	15	12	9	6	3
0	0	0	0	0	0	0
1	1	1	1	1	1	1
2	2	2	2	2	2	2
3	3	3	3	3	3	3
4	4	4	4	4	4	4
5	5	5	5	5	5	5
6	6	6	6	6	6	6
7	7	7	7	7	7	7
8	8	8	8	8	8	8
9	9	9	9	9	9	9

1. Events which could have influenced behaviour during rating period, e.g. epileptic attack.

2. Incidents or aspects of behaviour not adequately covered by rating scale.

<u>APPENDIX 3</u>

Details of 121 cases

APPENDIX 3

A - DATA ON SEVENTY-ONE SURGICAL CASES

Initials	M/F	Onset Age	Test Age	RPM Grade	Epilepsy T.L.	Epilepsy NonT.L.	Epilepsy None	Neurosurgical Procedure
L.A.	M	4	27	V	C			Central-Bilateral
G.B.	M	2	3	MA<2		✓		Right Temporal Lobectomy
J.B.	M	17	37	V		✓		Right Frontal Excision
A.B.	M	-	13	MA<2			None	Amygdalectomy
T.B.	M	7	39	IV	✓			Amygdalotomy
G.C.	M	19	29		E			" "
H.C.	M	2	9	MA<2	E			Right Temporal Lobectomy
J.CG.	F	4	22	V	E			" " "
F.C.	F	8	22	IV-		✓		Central-Unilateral
P.C.	M	16	20	III+	C			Left Temporal Lobectomy
J.C.	M	14	26	III-	✓			" " "
N.C.	M	26	37	I	✓			Amygdalotomy-Unilateral
P.C.	F	7	25	IV-	✓			Right Temporal Lobectomy
T.C.	F	36	48	IV	C			Central-Unilateral
S.C.	F	8	22	MA3½	✓			Amygdalectomy
J.D.	M	3	31	V		✓		Central-Bilateral
L.D.	M	3	12	MA4	E			Right Temporal Lobectomy
S.D.	F	3	20	IV		✓		Amygdalotomy
J.D.	M	17	52	V	✓			Left Temporal Lobectomy
S.Du	M	1	11	MA5		✓		Shunt Insertion
JMD.	F	13	20	III-	✓			Right Temporal Lobectomy
T.D.	M	11	11	V		✓		Left Occipital Lobectomy
G.L.	M	4	18	MA4	✓			Amygdalotomy
M.F.	F	9	14	V	✓			Right Fronto-Temporal Excision
H.F,	M	32	39	III-	✓			Amygdalotomy
M.F.	F	12	29	IV	✓			Right Temporal Lobectomy
L.F.	M	2	11	MA<2		C		Amygdalotomy
D.G.	M	8	17	V	✓			" "
W.G.	M	14	23	III-		✓		" "
D.G.	M	5	18	IV	✓			Right Temporal Lobectomy
P.G.	F	7	19	I	✓			Left " "
B.H.	M	2	8	MA4	E			Amygdalectomy
R.H.	M	3	6	MA3	E			Amygdalotomy
F.K.	F	1	16	III+	✓			" "
E.L.	M	27	35	III+		✓		Craniotomy

Initials	M/F	Onset Age	Test Age	RPM Grade	Epilepsy T.L.	Epilepsy NonT.L.	Epilepsy None	Neurosurgical Procedure
D.L.	F	40	40	V		✓		Fronto-Temporal Excision
I.L.	M	9	16	IV	✓			Right Temporal Lobectomy
W.L.	M	?	33	III-			?	Amygdalotomy
M.M.	F	8	17	V		✓		Central-Bilateral
E.M.	F	-	18	MA6			None	Amygdalotomy
E.M.S.	M	8	19	III	✓			" " " (Unilateral)
T.M.	M	17	37	III-		✓		" " "
D.M.	M	17	27	III-	C			R. Fronto-parietal Excision
P.Mc.	M	15	36	III+	✓			Left Temporal Lobectomy
J.M.	M	20	36	III-	C			Central+Amygdalotomy
G.M.	M	39	44	III+	C			Amygdalotomy
W.M.	M	14	29	V		✓		Central-Bilateral
D.M.	M	5	13	IV-		✓		" " " "
I.M.	F	21	27	III-	✓			Central+R.Temporal Lobectomy
E.M.	F	7	29	V	✓			Right Temporal Lobectomy
H.M.	M	6	12	III	✓			Amygdalectomy
J.M.	F	29	36	IV	✓			Left Temporal Lobectomy
D.P.	M	12	14	IV		✓		Central-Bilateral
G.P.	M	?	14	MA4		E		Amygdalectomy
A.P.	M	31	41	IV	C			Central-Bilateral
A.P.	M	10	22	III-	✓			Left Temporal Lobectomy
V.R.	F	20	25	IV-	✓			Amygdalotomy
B.R.	M	7	16	V	E			Central-Unilateral
M.R.	F	9	26	V	✓			Left Temporal Lobectomy
S.R.	F	41	45	III+	✓			" " "
P.S.	M	9	18	V	✓			R.Ant. Cingulectomy
R.W.	M	3	21	MA2½	·	✓		Hemispherectomy (Died)
J.S.	M	6	16	IV	✓			Amygdalotomy
C.S.	M	1	5	MA2½		✓		Shunt Insertion
J.S.	F	13	19	II	✓			Right Temporal Lobectomy
J.S.	M	10	17	V		✓		Shunt Insertion
S.S.	F	1	8	MA<2		C		Amygdalotomy
J.T.	M	14	18	III-		✓		Frontal Excision
V.T.	F	114	24	V	✓			Righr Temporal Lobectomy
A.T.	M	4	8	MA2½	✓			" " " " "
J.W.	M	-	17	MA 2			None	Amygdalectomy

Initials	M/F	Onset Age	Test Age	RPM Grade	Epilepsy T.L.	Epilepsy NonT.L.	Epilepsy None
A.B.	M	5	11	M.A.2½		✓	
R.B.	M	10	15	III-		✓	
A.B.	M	46	54	II	C		
E.C.	F	—	18	III-			?
J.C.	M	—	12	M.A 6			None
W.C.	M	-	22	M.A.4			"
A.C.	F	11	13	V		✓	
R.C.	M	11	28	III-	C		
G.C.	M	14	17	V	C		
J.D.	M	22	24	IV		C	
T.D.	M	14	27	IV		✓	
R.D.	M	19	24	III+		✓	
I.E.	M	13	17	V	E		
A.F.	M	7	8	M.A.6	✓		
T.F.	M	15	57	IV	C		
I.F.	F	33	34	II		✓	
J.G.	M	16	20	III+	✓		
B.G.	F	—	27	V			None
A.G.	M	7	9	III-		✓	
M.H.	F	19	37	III-	✓		
I.I.	F	2	6	M.A.4½		✓	
M.J.	M	10	13	V		✓	
D.J.	M	31	35	III+		✓	
M.K.	F	14	46	V		✓	
E.L.	F	20	35	IV	✓		
H.M.	M	—	25	M.A.4			None
G.M.	M	—	5	M.A.5⅓		E	
J.M.	M	-	17	IV		"	
R.M.	M.	45	48	II		C	
C.M.	M	?	54	III-			?
D.M.	M	47	48	II		C	
J.M.	M	15	25	II		✓	
P.M.	F	7	15	III		✓	
P.M.	M	9	12	IV	E		

APPENDIX 3 (cont'd) B - DATA ON FIFTY NONSURGICAL CASES

Init-ials	M/F	Onset Age	Test Age	RPM Grade	Epilepsy T.L.	NonT.L.	None
D.M	F	12	21	III-	C		
M.P,	F	14	29	II+	C		
M.P.	F	7	20	IV		C	
A.P.	M	?	16	IV			?
J.R.	M	14	20	V		C	
D.R.	M	12	15	MA.5⅓	✓		
J.R.	M	8	22	V		✓	
P.S.	F	10	13	III	E		
E.S.	M	19	41	III-		✓	
J.S.	M	3	29	MA<2		✓	
L.T.	F	2	14	IV-	C		
M.T.	M	13	24	III-	C		
C.W.	F	14	15	IV+		✓	
H.W.	F	14	15	IV+	E		
P.W.	M	14	15	IV		C	
W.W.	M	38	38	IV+		✓	

T.L.= Temporal Lobe Category NonT.L.=Non Temporal lobe category

None= Cases in whom no epileptic phenomena were demonstrated

✓ = Classification based on Clinical + EEG Evidence

C = Classification based on Clinical Evidence only

E = Classification based on EEG Evidence only

APPENDIX 4

Extra statistical analyses

TABLE XXXIX: Individual Reaction Time Results:comparison of pre-&post-operative mean scores.

Pt's Initials	Short/ Long term.	Simple Reaction Time						Vigilance		
		Right Hand			Left Hand					
		pre	post	t	pre	post	t	pre	post	t
Central lesion group										
L.A.	Short	.27	.28	.09	.29	.31	.4			
	Long	.27	.22	2.09 $p<.05$	.29	.19	3.5 $p<.001$			
F.G.	Short	.28	.3	.4	.26	.25	.1	.38	.42	.3
J.D.	Short	.29	.26	1.5	.27	.29	1.4			
	Long	.34	.33	.6	.48	.41	1.1			
M.M.	Short	.47	.36	3.7 $p<.001$	.40	.43	.7			
	Long	.47	.22	13.01 $p<.001$	.40	.31	2.73 $p<.05$			
J.M.	Short	.15	.18	1.5	.29	.19	4.3 $p<.001$			
D.H.	Short	.19	.3[illegible]	4.3 $p<.001$	.19	.37	2.7 $p<.05$	.34	.32	0.1
	Long	.19	.28	3.4 $p<.001$	.19	.25	2.5 $p<.05$			
D.P.	Short	.16	.16	.05	.18	.16	1.6	.26	.19	1.9
	2nd op.Short	.14	.16	1.0	.14	.15	1.0	.12	.22	4 $p<.001$
A.P.	Short	.18	.24	2.8 $p<.05$	.14	.15	.1	N.B. Pt. left-handed		
	2nd op.Short	.18	.18	.2	.14	.16	.5			
B.R.	Short	.20	.[illegible]	.4	.2	.24	1.4	.32	.44	1.1
	Long							.32	.22	1.3
	Distraction-S							.32	.4	1.2
	" " Long							.34	.22	2.4 $p<.05$
Amygdalotomy group										
G.C.	Short	.73	.34	4.65 $p<.001$	.65	.33	4.04 $p<.001$			
	Long	.73	.33	6.3 $p<.001$	.65	.4	3.06 $p<.02$			
B.B.	Short	.39	.27	1.2	.29	.18	2.2 $p<.05$			
W.L.	Short	.16	.20	3.2 $p<.02$	.17	.21	4.6 $p<.001$			
E.H.	Short	.38	.48	.8	.5	.56	.3			
J.M.	Short	.18	.13	2.6 $p<.05$	.16	.16	.32			
Temporal lobectomy group										
J.C.	Long	.2	.15	7.5 $p<.001$	.17	.15	1.9			
J.D.	Short	.18	.3	5.1 $p<.001$	.18	.28	6 $p<.001$			
	Long				.18	.3	15 $p<.001$			
P.C.	Short	.19	.39	2.8 $p<.05$	.16	.29	4.2 $p<.001$			
J.M.D.	Long	.28	.29	0.5	.39	.41	0.6			
G.P.	Long	.62	.53	0.7	.49	.64	2.0			
J.S.	Short	.28	.22	3.6 $p<.02$	.37	.21	6.3 $p<.001$	.31	.26	2.4 $p<.01$
V.T.	Short	.32	.42	2.5 $p<.01$	.28	.4	2.6 $p<.01$	.4	.54	3.3 $p<.01$

VISUAL ANALOGUE SCALE -INDIVIDUAL RESULTS

TABLE XL

Pre- and Post- Operative Mean Scores

Init-ials	No. pre	No. post	1.Depressed pre	post	t	2.Tired pre	post	t	3. Ill pre	post	t	4.Badly Treated pre	post	t	5. Tense pre	post	t
Central lesion group																	
T.C.	4	14	14	6	4,8*	75	76	.05	41	44	.2				29	14	1,3
M.M.	7	5	24	5	1,5	26	9	1,5	19	5	1,7	16	8	1,4			
J.M.	2	9	25	17	.4	75	56	1,1	67	18	2	10	3	1,6			
B.P.	2	5	15	10	.6	50	45	.1	19	15	.2	14	7	1,3	42	10	2,0
A.P.	10	20	39	51	1,2	70	77	1,0	17	50	5,8*	6	2	3,8*			
" "2nd op.	10	16	39	38	0,3	70	48	3,6*	18	40	4,5*	6	4	1,9			
B.R.	5	6	31	14	1,7	56	50	0,4	48	20	2,0	14	13	0,1	57	25	1,8
Amygdalotomy group																	
J.M.	9	2	17	5	0,6	56	20	3,2*	18	5	0,6	3	2	0,2			
S.D.	3	6	63	48	1,0	85	64	1,7	58	39	1,3						
W.L.	10	20	41	50	1,0	62	58	0,8	26	46	3,4*	17	41	2,9			
G.M.(ST)	9	20	8	27	3,8*	11	49	8,7*	11	30	4,7*	12	3	7,8*			
(LT)	9	11	8	47	5,9*	11	57	5,6*	11	52	6,8*	12	57	13,2*			
Temporal Lobectomy group																	
J.C.	19	19	22	21	.1	22	20	0,5	16	18	2,84*	19	23	2,36*			
P.C.	25	[illegible]6	49	58	1,11	69	67	0,4	32	43	1,8						
J.D.	9	12	8	37	2,9*	50	44	0,4	22	39	1,6	17	28	1,2			
J.M.D.	24	13	41	50	1,4	54	75	3,7*	27	42	2,2*	48	43	0,7			
"2ndop.	3	14	32	50	1,8	55	73	1,5	40	34	0,7	30	43	1,4	25	62	2,6*
P.G.	15	27	12	9	0,7	53	75	2,7	9	10	0,2	7	6	0,3			
J.S.	12	27	9	5	1,4	61	83	2,6*	7	3	2,9*	2	2	0,8	10	10	0,1
Exploratory Procedure Only																	
A.P.	30	28	17	2	2,7*	40	8	5,6*	16	0	4,3*	25	30	0,9	41	8	6,4*
C.M.	51	23	54	1	(.5*	84	66	4,6*	46	2	14,5*	13	1	8,7*			

*t value significant at least at 0,05 level

d.f.=(No. of pre-op. daily ratings +No. of post-op.daily ratings) -1

TABLE XLI: HARGREAVES NURSING RATING SCALE - Individual Results-Comparison of 2 periods of rating

a) Gogarburn Patients

Initials	Item 21 - Activity: 2x2 Table	X^2 (+Yates)	Signif. level	+/-	Item 22 - Talkativeness: 2x2 Table	X^2	Signif. level	+/-	Item 23 - Effective Contact: 2x2 Table	X^2	Signif. level	+/-
V.D.	0 0 / 12 7	Fisher	>·05		1 2 / 11 5	Fisher	>·05		4 2 / 8 5	Fisher	>·05	
J.M.	0 0 / 14 7	"	"		13 4 / 1 3	"	"		0 6 / 14 1	"	<·01	−
M.B.	2 0 / 12 6	"	"		6 0 / 8 7	"	"		3 1 / 11 5	"	>·05	
M.D.	10 0 / 4 6	"	<·01	+	3 0 / 11 7	"	"		6 1 / 8 5	"	"	
J.A.	10 3 / 3 2	"	>·05		10 5 / 4 1	"	"		10 5 / 4 1	"	"	
G.C.	0 0 / 14 7	"	"		5 4 / 8 3	"	"		[illegible] 5 / 14 2		<·01	−
E.S.	7 2 / 6 4	"	"		12 2 / 1 4	"	<·05	+	[illegible] [illegible] / 6 0		>·05	
A.D.	7 2 / 4 4		"		1 2 / 10 4	"	>·05		5 3 / [illegible] 3		"	
M.F.	3 0 / 11 6		"		4 0 / 10 6	"	"		[illegible] 0 / [illegible] [illegible]		<·01	+
J.G.	3 0 / 9 5	"	"		9 6 / 3 0	"	"		11 0 / 1 6	"	<·01	+
V.S.	0 1 / 14 5	"	"		1 5 / 13 0	"	<·01	+	[illegible] 0 / 3 5	"	>·05	
G.B.	0 0 / 14 7	"	"		0 6 / 14 1	"	<·01	−	10 6 / 4 1	"	"	
J.McD.	1 0 / 10 7		"		11 3 / 0 4	"	<·05	−	5 0 / 6 7		"	
M.P.	6 0 / 8 7		<·05	+	14 7 / 0 0		>·05		8 0 / 6 7		<·01	+
A.B.	14 3 / 0 4	"	<·01	−	13 1 / 1 6		<·01	−	9 3 / 5 4		>·05	
M.McG.	0 0 / 12 5		>·05		10 6 / 2 0	"	>·05		0 0 / 12 5	"	"	
M.L.	11 0 / 2 7	"	<·01	−	1 1 / 12 6		"		12 7 / 2 0		"	
C.R.	13 5 / 1 2	"	>·05		13 6 / 1 1		"		11 6 / 3 1		"	
A.N.	4 4 / 10 3		"		13 7 / 2 0		"		7 0 / 7 7		<·01	+
A.S.	0 6 / 12 0		<·01	−	0 0 / 13 7		"		6 1 / 8 6		>·05	
F.McG.	− −	"	− −		2 5 / 12 2	"	<·05	−	− −		− −	
R.H.	4 0 / 10 7		>·05		3 5 / 12 2		<·05	−	2 0 / 12 7		>·05	
R.T.	6 0 / 8 7	"	<·05	+	4 2 / 10 5	"	>·05		11 2 / 3 5		<·05	+
M.S.	1 2 / 13 5	"	>·05		4 3 / 10 4		"		9 2 / 5 5		>·05	
A.C.	11 7 / 1 0	"			3 7 / 9 0		<·01	−	6 7 / 6 0		<·05	−
K.H.	3 0 / 10 7	"	"		1 6 / 10 7	"	>·05		14 7 / 0 0		>·05	
C.C.	[illegible] 1 / [illegible] 6		"		4 7 / 9 0	"	<·01	−	4 0 / [illegible] 7		"	
R.D.	0 0 / 14 7	"	"		13 7 / 0 0		>·05		14 0 / 0 7		<·01	+
D.M.	3 6 / 10 0	"	<·01	−	13 7 / 0 0		"		14 7 / 0 0		>·05	
W.A.	[illegible] 0 / 0 7	"	<·01	+	4 0 / 6 7		"		10 6 / [illegible] 0		"	
G.M.	13 0 / 0 7	"	<·01	+	13 7 / 0 0		"		14 0 / 0 7		<·01	+

Each 2x2 Table is cast as follows:-

	1st Period	2nd Period
Rating 0-3		
Rating 4-9		

Only cell frequencies are shown in the body of the table.

Stat. test: X^2+Yates' correction, or Fisher test for small groups.

On items 5-8, 18, '+' indicates increased disturbance

On items 21-24 '+' represents improvement.

TABLE XLI(cont'd): HMRS Individual Results-Gogarburn Patients-Comparison of 2 periods of rating

(Each 2x2 Table is cast as on previous page, except that the upper row now gives frequency of zero ratings, and lower row, gives frequency of any positive rating, 1-9)

Initials	Item 5 - Angry Talk: 2x2 Table	x^2 (+Yates correction)	Signif. level p	+/-	Item 6 - Angry Manner: 2x2 Table	x^2	Signif. level p	+/-	Item 7 - Uncooperative: 2x2 Table	x^2	Signif. level	+/-	Item 18 - Antisocial: 2x2 Table	x^2	Signif. level	+/-
V.D	4 2 / 8 5	0.08	>.05		2 2 / 10 5	0	>.05		4 3 / 8 4	0	>.05		2 5 / 12 2	4.5	<.05	−
J.M.	14 1 / 0 6	12.8	<.01	+	12 0 / 2 7	10.7	<.01	+	12 0 / 2 7	10.7	<.01	+	11 0 / 3 7	·8	<.01	+
M.B	14 1 / 0 5	11.4	<.01	+	14 1 / 0 5	11.4	<.01	+	12 3 / 2 3	1.2	>.05		11 0 / 3 7	8.6	<.01	+
M.D	10 1 / 4 5	Fisher	<.05	+	13 2 / 1 4	5.07	<.05	+	10 1 / 4 5	Fisher	<.05	+	3 0 / 11 6	·02	>.05	
J.A.	10 6 / 4 0	0.72	>.05		10 5 / 4 0	0.49	>.05		4 2 / 10 4	0.1	>.05		8 6 / 6 0	1.91	>.05	
G.C.	14 0 / 0 7	16.74	<.01	+	8 0 / 6 7	4.26	<.05	+	14 6 / 0 1	0	>.05		0 1 / 14 6	0.1	>.05	
E.S.	8 6 / 3 3	0.03	>.05		9 0 / 5 5	Fisher	<.05	+	6 2 / 8 4	0	>.05		5 2 / 9 4	[illegible]·01	>.05	
A.D.	8 7 / 3 0	0.7	>.05		2 0 / 9 6	0.1	>.05		7 [illegible] / 4 0	1.1	>.05		4 3 / 7 3	0.6	>.05	
M.F	6 6 / 7 0	Fisher	<.05	−	9 6 / 5 0	1.26	>.05		5 6 / 9 0	4.65	<.05	−	6 0 / 8 6	1.9	>.05	
J.G	4 0 / 8 6	1.0	>.05		12 5 / 0 1	0.13	>.05		6 1 / 6 5	0.7	>.05		12 4 / 1 2	0.5	>.05	
V.S	8 0 / 6 6	Fisher	<.05	+	12 2 / 0 6	9.53	<.01	+	9 0 / 5 7	5.4	<.05	+	10 0 / 4 6	5.9	<.05	+
C.B	10 0 / 4 7	6.89	<.01	+	8 0 / 6 6	Fisher	<.05	+	15 1 / 0 5	12.1	<.01	+	3 6 / 10 1	5.4	<.05	−
J.McD.	13 5 / 1 2	0.4	>.05		12 7 / 1 0	0.1	>.05		12 7 / 1 0	0	>.05		14 1 / 0 6	16.8	<.01	+
M.P.	7 3 / 7 4	0.02	>.05		7 5 / 7 2	0.2	>.05		14 7 / 0 0	0	>.05		13 6 / 1 1	0	>.05	
A.S	3 6 / 11 1	5.46	<.05	−	2 6 / 12 1	7.2	<.01	−	12 0 / 2 7	10.7	<.01	+	10 6 / 4 0	0.2	>.05	
M.McG	12 6 / 0 0	0	>.05		9 6 / 3 1	0	>.05		11 7 / 1 0	0	>.05		8 5 / 3 1	0.01	>.05	
M.L	11 7 / 2 0	0.3	>.05		9 7 / 4 0	1.1	>.05		8 0 / 5 7	4.8	<.05	+	2 0 / 12 7	0.06	>.05	
C.R	4 3 / 10 4	0.42	>.05		4 2 / 10 5	0.26	>.05		9 5 / 5 2	0.02	>.05		9 6 / 5 1	0	>.05	
A.N	4 7 / 10 0	6.9	<.01	−	3 7 / 11 0	8.6	<.01	−	6 3 / 7 4	0	>.05		2 7 / 12 0	14.0	<.01	−
A.S.	6 0 / 8 7	2.36	>.05		6 0 / 8 7	2.3	>.05		5 2 / 9 5	0	>.05		0 7 / 14 0	21.0	<.01	−
F.McG.	2 7 / 12 0	10.7	<.01	−	11 7 / 3 0	0.4	>.05		12 6 / 2 0	0	>.05		14 7 / 0 0	0	>.05	
R.H	1 7 / 13 0	13.3	<.01	−	0 7 / 14 0	16.7	<.01	−	0 7 / 13 0	15.8	<.01	−	9 7 / 5 0	1.6	>.05	
R.T.	11 5 / 2 2	0.01	>.05		13 7 / 1 0	0.1	>.05		12 3 / 2 4	2.3	>.05		5 3 / 9 3	0	>.05	
[illegible] S	7 0 / 6 7	Fisher	<.01	+	2 2 / 11 4	0.08	>.05		7 0 / 6 7	Fisher	<.05	+	4 6 / 10 1	4.03	<.05	−
A.C.	12 7 / 0 0	0	>.05		0 0 / 2 7	0	>.05		7 2 / 5 3	0	>.05		2 0 / 10 7	1.3	>.05	
K.H.	11 1 / 3 6	5.46	<.05	+	[illegible] 1 / 4 6	4.03	<.05	+	14 [illegible] / 0 6	12.8	<.01	+	3 1 / 11 6	0.03	>.05	
C.C.	14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 0 / 0 7	16.7	<.01	+
R.D.	14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05	
[illegible]	14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05	
[illegible].A.	14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05	
G.A	14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05		14 7 / 0 0	0	>.05	

TABLE XLI (cont'd) : HARGREAVES NURSING RATING SCALE - Individual Results - b)Comparison of pre- and post-operative rating periods

(In each 2x2 Table, left hand column gives pre-op. data, right hand column post-op. Upper row gives frequency of 0-3 ratings, lower row, ratings of 4-9)

Initials	Item 5 - Angry Talk: 2x2 Table	X^2	Signif. level	+/-	Item 6 - Angry Manner: 2x2 Table	X^2	Signif. level	+/-	Item 7 - Uncooperative: 2x2 Table	X^2	Signif. level	+/-
Amygdalotomy Patients												
G.C.	47 44 / 18 3	6·79	<·01	-	51 43 / 14 4	2·53	>·05		42 45 / 23 2	13·5	<·001	-
S.D.	17 27 / 11 20	0	>·05		24 48 / 4 19	1·43	>·05		21 48 / 7 19	0	>·05	
G.E.	12 25 / 6 2	3·35	"		7 24 / 11 3	10·37	<·01	-	6 23 / 12 4	10·5	<·01	-
D.G.	14 7 / 1 0	0·15	"		14 7 / 1 0	Fisher	>·05		13 7 / 2 0	0·04	>·05	
W.L.	7 12 / 0 1	0·1	"		7 12 / 0 1	Fisher	>·05		7 12 / 0 1	Fisher	"	
E.M.	11 0 / 1 5	9·3	<·001	+	7 0 / 5 5	Fisher	<·05	+	3 0 / 9 5	"	"	
G.M.	11 14 / 0 0	0	>·05		11 14 / 0 0	Fisher	>·05		11 10 / 0 5	"	"	
Other Procedures												
J.C.	11 19 / 0 10	0	"		11 23 / 0 6	1·3	>·05		11 29 / 0 0	0	>·05	
A.Pi.	15 45 / 4 4	1·12	"		18 48 / 1 1	0	"		19 48 / 0 1	0·2	"	
A.Po.	31 30 / 0 1	0	"		31 30 / 0 1	0	"		31 31 / 0 0	0	"	
C.M.	66 29 / 3 5	2·12	"		66 28 / 3 6	3·5	"		67 33 / 2 1	0	"	

Initials	Item 8 - Overall Anger: 2x2 Table	X^2	Signif. level	+/-	Item 18 - Antisocial: 2x2 Table	X	Signif. level	+/-
Amygdalotomy Patients								
G.C.	46 42 / 19 5	4·5	<·05	-	38 42 / 26 5	10·6	<·01	-
S.D.	13 47 / 7 20	0·02	>·05		24 43 / 4 24	3·4	>·05	
G.E.	7 26 / 11 1	15·38	<·001	-	6 22 / 12 5	8·7	<·01	-
D.G.	12 7 / 3 0	Fisher	>·05		14 7 / 1 0	Fisher	>·05	
W.L.	7 12 / 0 1	"	"		7 12 / 0 1	"	"	
E.M.	6 4 / 6 1	"	"		3 0 / 9 5	"	"	
G.M.	—	—	—		9 7 / 2 8	"	"	
Other Procedures								
J.C.	-	-	-		11 18 / 0 11	4·0	<·05	+
A.Pi.	-	-	-		19 18 / 0 1	0	>·05	
A.Po.	31 31 / 0 0	0	>·05		31 31 / 0 0	0	"	
C.M.	40 37 / 2 7	1·78	"		66 28 / 3 6	3·5	>·05	

Initials	Item 21 - Activity: 2x2 Table	X	Signif. level	+/-	Item 22 - Talkativeness: 2x2 Table	X^2	Signif. level	+/-
Amygdalotomy Patients								
G.C.	40 33 / 25 14	0·5	>·05		62 33 / 3 14	11·5	<·001	-
S.D.	6 19 / 22 48	0·19	>·05		10 11 / 28 56	3·7	>·05	
G.E.	5 19 / 13 8	6·2	<·02	+	13 7 / 5 20	7·6	<·01	+
D.G.	12 0 / 3 7	Fisher	<·01	+	6 0 / 9 7	Fisher	>·05	
W.L.	2 1 / 5 12	"	>·05		6 2 / 1 11	"	<·01	+
E.M.	4 5 / 8 0	"	<·05	+	5 0 / 7 5	"	>·05	
G.M.	0 3 / 11 12	"	"		0 3 / 11 12	"	"	
Other Procedures								
J.C.	10 24 / 1 5	1·5	>·05		6 12 / 5 17	0·5	>·05	
A.Pi.	15 2 / 4 47	40	<·01	+	12 22 / 7 27	1·1	"	
A.Po.	31 31 / 0 0	0	>·05		31 25 / 0 6	4·6	<·05	-
C.M.	14 3 / 55 31	1·42	"		1 3 / 68 31	1·6	>·05	

TABLE XLI (cont'd) : HARGREAVES NURSING RATING SCALE - Individual Results - b) Comparison of pre- and post-operative rating periods

(Each 2x2 Table is cast as on previous page, except that for items 5-8,18, the upper row now gives frequency of zero ratings, the lower, gives the frequency of any positive rating, from 1-9).

Initials	Item 5 - Angry Talk: 2x2Table	X^2	Signif. level	+/-	Item 6 - Angry Manner: 2x2Table	X^2	Signif. level	+/-	Item 7 - Uncooperative: 2x2Table	X^2	Signif. level	+/-
Amygdalotomy Patients												
G.C.	12 13 / 53 34	0.85	>.05		13 12 / 52 35	0.21	>.05		6 14 / 59 33	6.5	<.02	-
S.D.	1 20 / 27 47	6.46	<.02	-	1 21 / 27 46	7.06	<.01	-	3 22 / 25 45	3.9	<.05	-
G.E.	3 11 / 15 16	1.9	>.05		1 13 / 17 14	7.3	<.01	-	0 10 / 18 17	6.5	<.02	-
D.G.	13 7 / 2 0	0.04	"		12 7 / 2 0	0.06	>.05		10 7 / 5 0	Fisher	>.05	
W.L.	4 7 / 3 7	0.02	"		6 7 / 1 7	Fisher	"		2 8 / 5 6	"	"	
E.M.	1 0 / 11 5	0.2	"		2 0 / 10 5	"	"		0 0 / 12 5	"	"	
G.M.	18 0 / 3 14	11.8	<.01	+	9 0 / 2 14	14.5	<.01	+	1 0 / 10 14	"	"	
Other Procedures												
J.C.	10 7 / 1 22	11.9	<.001	+	11 11 / 0 18	10.0	<.01	+	6 19 / 5 10	0.07	>.05	
A.Pi.	10 28 / 9 21	0.0	>.05		11 37 / 8 12	1.28	>.05		6 40 / 13 9	13.5	<.001	-
A.Po.	31 23 / 0 8	7.0	<.01	+	31 24 / 0 7	5.79	<.02	+	31 30 / 0 1	0.01	>.05	
C.M.	38 22 / 31 12	0.5	>.05		42 19 / 27 15	0.07	>.05		55 22 / 14 12	1.98	"	

Initials	Item 8 - Overall Anger: 2x2Table	X^2	Signif. level	+/-	Item 18 - Antisocial: 2x2Table	X^2	Signif. level	+/-	Item 23 - Effective Contact: 2x2Table	X^2	Signif. level	+/-	Item 24 - Gen. Effectiveness: 2x2Table	X^2	Signif. level	+/-
Amygdalotomy Patients																
G.C.	10 10 / 55 37	0.3	>.05		2 5 / 63 42	1.52	>.05		49 28 / 16 17	1.6	>.05		9 1 / 56 44	3.05	>.05	
S.D.	1 15 / 20 52	2.2	"		0 10 / 28 57	3.2	"		20 34 / 8 33	2.6	"		23 46 / 5 21	1.1	"	
G.E.	1 13 / 17 14	7.26	<.01		3 3 / 15 24	0	"		13 8 / 5 19	6.25	<.02	+	15 22 / 3 5	0.02	"	
D.G.	10 7 / 4 0	Fisher	>.05		6 7 / 8 0	Fisher	<.05	-	14 5 / 1 2	Fisher	>.05		14 3 / 1 7	0.01	"	
W.L.	3 8 / 4 5	"	"		7 11 / 0 3	"	>.05		7 9 / 0 5	"	"		7 9 / 0 5	Fisher	"	
E.M.	0 0 / 12 5	"	"		0 0 / 12 5	"	"		10 0 / 2 5	"	<.01	+	12 0 / 0 5	"	<.01	+
G.M.	-	-	-		5 1 / 6 14	"	<.05	+	4 13 / 7 2	"	<.05	-	9 7 / 2 8	"	>.05	
Other Procedures																
J.C.	-	-	-		5 6 / 8 21	0.48	>.05		2 28 / 11 1	25	<.01	+	0 11 / 11 18	4.0	<.05	-
A.Pi.	-	-	-		4 4 / 15 15	0	"		18 30 / 1 19	5.8	<.01	+	11 0 / 8 49	5.2	<.01	+
A.Po.	31 23 / 0 8	7.0	<.01	+	31 27 / 0 4	2.4	"		4 3 / 27 28	0.1	>.05		9 9 / 22 22	0	>.05	
C.M.	30 16 / 12 18	3.7	>.05		51 22 / 18 12	0.5	"		26 13 / 43 21	.01	"		44 13 / 25 21	6.0	<.05	+

APPENDIX 8

Copies of papers presented and published
in the course of the study

In: Psychosurgery

Eds: Hitchcock, E., Laitinen, L., Vaernet, K.,

Charles C. Thomas Springfield, Illinois 1972

Chapter 14

PREOPERATIVE AND POSTOPERATIVE ASSESSMENT AND MANAGEMENT OF PSYCHOSURGICAL PATIENTS

EDWARD HITCHCOCK, G. W. ASHCROFT, VALERIE M. CAIRNS, AND L. G. MURRAY*

INTRODUCTION

We wish to report the attempt by a group composed of psychiatrists, a neurosurgeon, and a psychologist to develop a system for the management and assessment of patients with epilepsy and behavior disturbances treated by temporal lobe surgery. The work reported* represents only the start of a much more extensive program and since the total number of patients considered is only 10, no firm conclusions are possible regarding the efficacy of the surgical procedure, although we hope that pointers for the future are emerging. Initially we accepted the hypothesis that surgery of the amygdala would produce improvement in the aggressive behavior of some epileptic patients. This apparently simple hypothesis attempts at the same time to localize aggression and also to generalize the concept, so that the *common* features of the aggressive responses shown by different individuals were emphasised, the differences minimized. In many patients the aggression did not appear in unprovoked, nonspecific fashion; rather they tended to exhibit periods of extreme irritability during which their frustration tolerance was greatly reduced and aggression easily provoked. The stimuli which provoke aggression in one individual show a considerable specificity for that patient. For example, one patient reacts to authority figures, another more to females than to males.

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In concentrating too much on "aggression" as the *major* behavioral disturbance we encountered difficulties. Most of the patients showed, in addition, secondary behavior disturbances, apathy, stealing, and other affective disturbances. In addition certain personality features such as marked hysteroid personality traits or extreme dependency complicate the assessment and management. We now believe that our preoperative assessment of patients must involve a very detailed study of these "secondary" variables and that the program of rehabilitation must be largely designed to tackle these problems.

Our experiences are similar to studies described by Sweet *et al.*[12] and Horowitz *et al.*[9]

METHODS

It was decided at an early stage in the project that selection would be made by the neurosurgeon with patients being referred only from neurological or general medical but *not* from psychiatric sources. Patients with epilepsy were selected for the study because of the severe social disruption resulting from their behavior and the failure of other methods of management. At the start of the study the role of the psychiatric team was to be one solely of preoperative and postoperative assessment but a more active role in therapy was an inevitable development as the investigation progressed.

The surgical procedure involved the bilateral stereotactic placement of electrodes within the amygdala and its destruction by a radio-frequency current. Initially the Leksell frame was used with the electrode passing through frontal burrholes. Subsequently, a more direct route via the lateral aspect of the temporal lobe was chosen. Placement was regarded as inaccurate on one side in one patient and was performed under a general anaesthetic in only two patients.

Patients were examined clinically and investigated neurologically by EEG, x-ray, isotope scan, etc.

Where possible, a preliminary psychiatric interview was carried out before admission. In-patient treatment and observation was divided into 3 periods.

In the first period, patients were admitted for 4 weeks to a specialized psychiatric unit for an intensive program of investigation: first, a series of clinical psychiatric examinations for diagnostic purposes; secondly, a program of observation of the patient under a variety of ward situations, involving the study of his interaction with other patients, visitors, and male and female staff. A record was also kept of the frequency and of the characteristics of his attacks. In addition, the relationship of any change in mood or aggressive behavior to the occurrence of fits was noted. The information from all these techniques of assessment was combined to provide a clinical formulation of each case.

Patients were transferred during the second period to the neurosurgical unit for operation and related physiological studies, usually for a period of one to two weeks, during which no psychiatric studies were made.

I. COGNITIVE ASSESSMENT

	TEST	DESCRIPTION	
1.	Raven's Progressive Matrices (R.P.M.)	Test of present capacity for intellectual activity	Complementary tests
2.	Mill Hill Vocabulary Scale (M.H.V.)	Test of fund of information acquired, and ability for verbal communication	
3.	Porteus Maze Test	Paper and pencil performance test of foresight and planning capacity	
4.	Graham-Kendall Memory for Designs (M.F.D.)	Test of ability to reproduce simple geometric designs from memory, immediately after presentation	
5.	Sentence Repetition	Test of ability to repeat orally spoken sentence	
6.	Williams - New Word Learning Test	Test of paired associate learning	
7.	Williams - Delayed Recall Test	Test of retention; providing measure of amount of reinforcement necessary to produce recollection	

Figure 14-1. Cognitive assessment.

The patient was returned to the psychiatric unit for the third period for reassessment, the start of a rehabilitation program, nonstructured observation combined with psychological assessments, and the use of behavior rating scales completed by the nursing staff.

Routine psychological assessments were found to be quite inadequate and a more extensive assessment procedure was devised with particular emphasis on observational techniques, self-ratings, and methods yielding information about the process of change over a period of time.

Assessment can be divided into three categories: a) assessment carried out at fixed points in time preoperatively and postoperatively; b) a more intensive assessment of the patient during the immediate preoperative and postoperative period as a psychiatric in-patient, through nurse rating and self-rating techniques; c) assessment during the operative procedure itself by content analysis of tape recorded samples of the patient's speech.

In the tests of cognitive function (Fig. 14-1) we found no change and we will not detail them as they are all well-established methods.

Section A (Fig. 14-2) gives details of the methods of *personality assessment*. Section B shows two techniques for *intensive assessment as a psychiatric in-patient*. The first is a slightly modified version of the Hargreaves Nursing Rating Scale. Figure 14-3 covers 3 of the 20 items in the scale. It illustrates the point that nurses are rating *overt* behavior and are given descriptions of behavioral acts on which to base their rating on a 10-point scale. The second (Fig. 14-2. B2) is a more extensive form of the Visual Analogue Scale. Figure 14-4 is an example of a form completed by a patient.

RESULTS

Air encephalography revealed slight atrophy and dilatation of the temporal horn in 2 of the 8 examinations. These abnormalities coexisted with EEG evidence of abnormality in that region.

EEG, both scalp and sphenoidal leads, revealed abnormalities in 8 of 9 patients with focal evidence of temporal lobe disturbance in 7.

The results of the clinical investigations have been satisfactory

II. PERSONALITY AND BEHAVIOUR ASSESSMENT

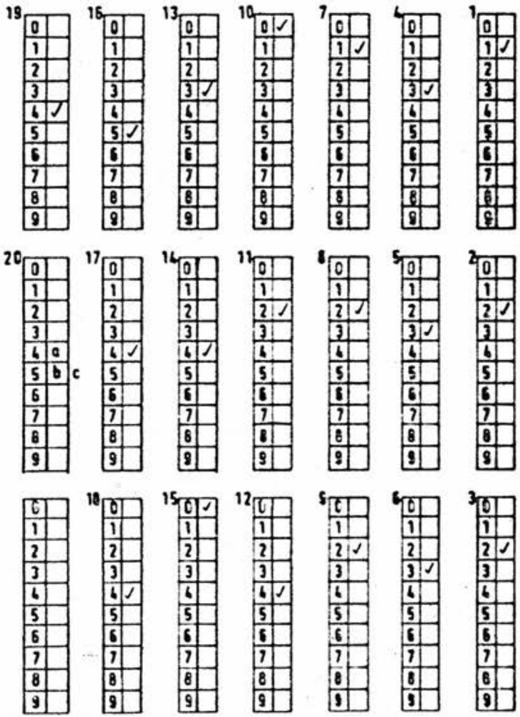
	TEST	DESCRIPTION
A. 1.	Cattell's 16 Personality Factor Questionnaire (Forms C & E) (16 PF)	An objectively scorable test - a multidimensional measure of 16 distinct primary personality factors
2.	Zuckerman & Lubin's Multiple Affect Adjective Check List (M.A.A.C.L.)	Self-administered test providing measures of 3 negative affects - anxiety, depression and hostility
3.	Porteus Maze Test	- also provides a qualitative score - a measure of carelessness distinguishing between socially maladjusted and normally adjusted groups
4.	Gottschalk Scales	Content analysis of tape-recorded samples of speech, measures of hostility, anxiety, etc.
5.	Personality & Personal Illness Questionnaires (Caine, Foulds & Hope). a) Symptom-Sign Inventory (S.S.I.) b) Hysteroid Obsessoid Questionnaire (H.O.Q.) c) Hostility & Direction of Hostility Questionnaire (H.D.H.Q.)	Questionnaires measuring 3 levels of psychological functioning - symptoms, personality and attitudes
B. 1.	Hargreaves Nursing Rating Scale	Designed for daily use by psychiatric nurses, covering wide range of psychopathology, with 24 (20) items, each rated on a 10 point scale
2.	Visual Analogue Scale (adaptation of Zealley & Aitken Scale)	Designed for daily use providing index of change in self-ratings on various continua.

Figure 14-2. Personality and behavior assessment.

in eliminating gross lesions such as tumor, but it may be preferable to keep to a routine order of investigations so that the influence of such attention is comparable between patients.

One patient developed a complication directly related to target

Nursing Rating Scale: Record Form



4. Grumpy, resentful, sarcastic, abusive

1-3 : Low. Occasionally sarcastic, snappish, grumpy, demanding.

4-6 : Mod. An angry outburst: outspoken, annoyed several times during the day, or persistently grumbling or sarcastic.

7-9 : High. Verbally assaultive or abusive more than once during the day or a large proportion of his talk is intensely angry; the person who is target of anger need not be present.

5. Annoyed face, threatening posture, striking another

1-3 : Low. Annoyed facial expression; sullen; brusque or abrupt in interpersonal contacts.

4-6 : Mod. Occasional intense, glaring, threatening expression, or moderate angry expression throughout the shift; slamming around, kicking or banging objects; noisy but non-destructive.

7-8 High. Threatening expression for several hours; hits or grapples with another person; destroys property.

9 High. Serious destruction of property or physical attack on another.

6. Stubborn, verbally resistive, physically resistive

1-3 : Low. Avoiding obligations; failure to live up to established contracts; mild stubborness; resistive though claims willingness.

4-6 : Mod. Failure to follow orders; verbally resistive, or sullenly defiant.

7-9 : High. Physically refusing to conform to staff requests; physically resistive.

Figure 14-3. Nursing rating scale: Record form (Items 5-8).

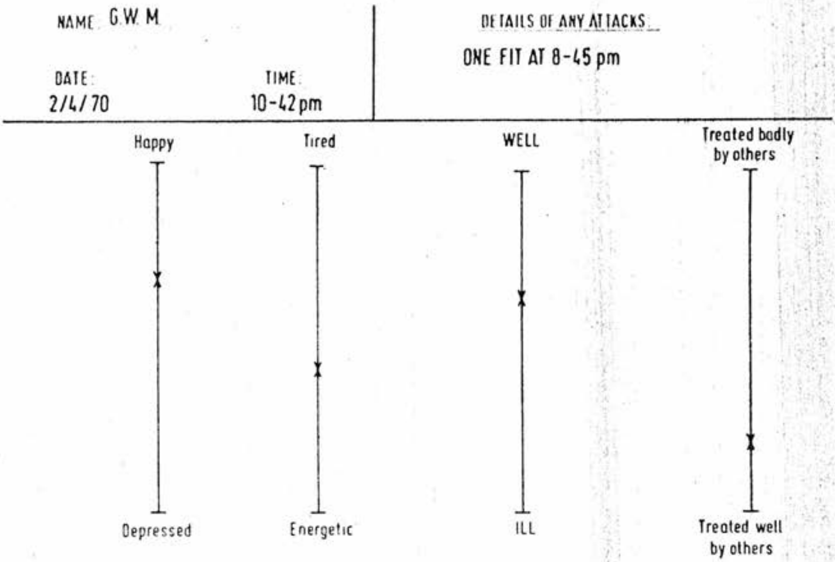


Figure 14-4. Visual analogue scale: Record form.

lesion making (transient third nerve paresis). Two patients showed signs of hormone imbalance postoperatively.

In only 2 of the 6 cases of preoperative physical aggression did this persist at postoperative follow-up. Mood disturbance persisted in 4 cases, disappeared postoperatively in one case and appeared postoperatively in 2 cases.

Only 4 patients were studied in detail by the present group of psychiatric observers. Rather than attempt to give a statistical analysis, which would be quite inappropriate with the small numbers, a summary is given.

All 4 patients suffered from intractable temporal lobe epilepsy, but with a wide range of clinical manifestation of seizures. In 2 patients preoperative physical aggression was related to seizures; in 1 of these patients interictal behavior was hyperkinetic and antisocial. This case did not show improvement in behavior in the immediate postoperative period, but at follow up, one year later, physical aggression had disappeared. He is hospitalized but working satisfactorily in industrial therapy.

In the other case of preoperative physical aggression, interictal pattern was consistent with an adolescent behavior disturbance. In this case there was no postoperative physical aggression but antisocial behavior continued. At follow up, one year later, she is living at home with an improved relationship with her parents, but has not yet been successful in settling down in employment.

The other 2 cases showed dependent hysteroid personality features preoperatively. Both underwent a brief period of elation and disinhibition immediately postoperatively, but on return home underwent a turbulent phase with suicide threats in one, depression in the other, and the development of paranoid symptoms in both. One is improving 8 months after operation, with the current program of rehabilitation, and the other improved 4 months after operation with a change in his home situation.

The results of psychological assessment are best illustrated by one of the above mentioned cases of dependent-hysteroid personality. A personality profile (Fig. 14-5) shows that postoperatively there is an increase of the following:

1. Emotional lability (Factor C).
2. Submissiveness (Factor E).
3. Tendermindedness (Factor I).

On the Visual Analogue Scale (Fig. 14-6) it is apparent that the markings for the happy/depressed line fluctuate more postoperatively than preoperatively, suggesting that the patient felt more depressed in the postoperative period. However, drug changes occurred in this period. In "treatment by other people" there is little preoperative and postoperative difference. However, on days when seizures occurred (black squares) he felt less well-treated than on seizure-free days. Similar results have been obtained from other patients. By the end of the second postoperative month, scores were less fluctuant, becoming variable again on return home.

Despite changes in self-rating, results on the Hargreaves Nursing Rating Scale showed little change in the patient's overt behavior.

Tape recordings of speech during operation showed that no emotional responses were evoked during stimulation or immediately after coagulation. However, use of this method with an-

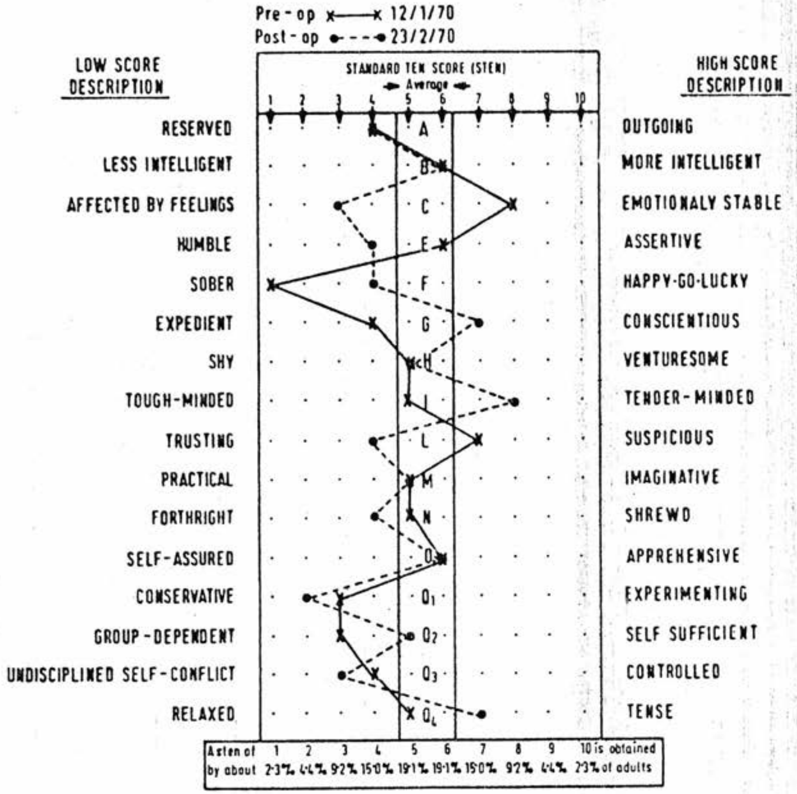


Figure 14-5. 16 P.F.—Test profile.

other patient yielded a record of emotional response, including some aggression, during stimulation.

Assessment of cognitive functioning showed no change.

DISCUSSION

Most psychologists and psychiatrists remain more skeptical about cerebral localization of function in the human brain than are neurosurgeons, and few of them would endorse Halstead's[7] idea, "for every twisted thought there is somewhere in the brain a twisted protein molecule." Nevertheless, in this cooperative study there is an opportunity to confirm or refute hypotheses in this matter provided by a neurosurgeon destroying the amygdaloid nucleus. This report has emphasized difficulties rather than suc-

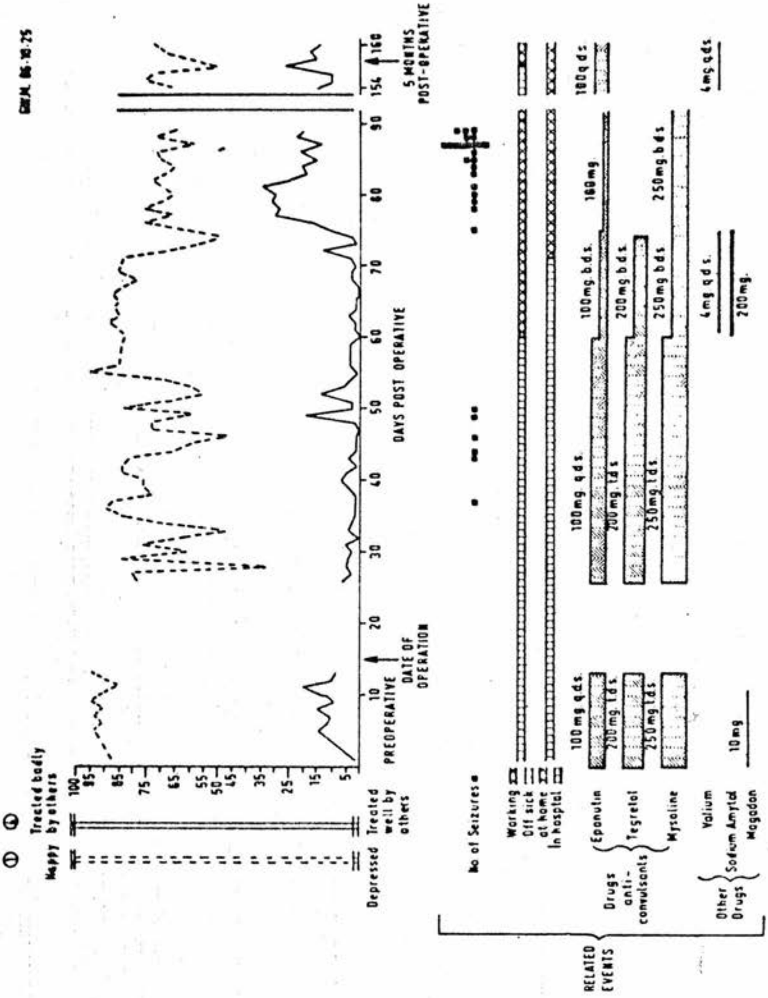


Figure 14-6. Visual analogue scale results (Lines 1 and 4).

cesses but the project has permitted speculations and tentative conclusions.

Measurement of change in behavior sounds a relatively simple procedure. Our aim was to find methods of assessment which we could replicate from a study of the previous literature on psychosurgery. Although the majority of studies in the published literature do include much material on change in psychiatric status and behavior, there is surprisingly little detail on the methods of assessment, apart from clinical review. Several authors do make use of rating scales, but most fail to give details of status of observers and period of observation. It has been necessary to adapt a variety of existing measures for the particular problems of our study.

Sweet *et al.*[12] have emphasized the difficulties of the in-patient management of this group. Many of their patients were discharged without operation because of the inability of the hospital to contain their behavior or the hospital administration to tolerate their disrupting influence. Our group to date have been no exception to this rule.

Interaction between patient and environment set up as a result of his pathological irritability becomes a known pattern of behavior to patient and relatives. Expectations of the operation, if they include complete and immediate return to normal "adaptation," can prove disastrous to all. The facilities required for further rehabilitation will vary with each patient and it would be wrong to attempt a uniform program. In general, however, a psychotherapeutic program is developed to enable a patient and, where appropriate, his family to readjust and to unlearn those abnormal patterns of behavior which developed as a result of his pathological aggression and perhaps to take advantage of improvement when it has occurred in the patient's basic affective responses. Joint staff discussion minimizes the anxiety in the neurosurgical unit asked to take over potentially violent patients. The feeling that the psychiatric unit is available to make intervention at short notice in the case of difficulties also helps in the management of difficult patients, and in promoting understanding between the two clinical groups. The appearance of physical aggressive acts will depend on the response of the environment, the patient's frustration tolerance being so low that any opposition may provoke an aggressive outburst. During these periods the patient may show a particular vulnerability to certain situations indicating individual psychopathology.

In the present study there is an opportunity to investigate the relationship between seizures and behavior disorders. Frequently one comes across a diagnosis of "epilepsy and associated behavior disorder" with little effort to analyze whether in fact the behavioral abnormality is an integral part of the clinical or subclinical seizure process or whether it is part of a more enduring personality constellation. Some studies have indicated an inverse relationship between the behavior disorder and the number of epileptic seizures, e.g. Bailey and Gibbs.[1] Flor-Henry[3] postulated that frequent ictal discharges were, in fact, both specifically and generally antipsychotic. Other workers[13] have shown that where after-operation seizures are best controlled, behavior also showed the greatest improvement. If, using the methods of assessment already described, it is possible to establish a relationship between seizure patterns and behavior preoperatively and postoperatively it might be possible to reach certain conclusions about the underlying pathophysiology.

Finally, we would stress the complex nature of the aggressive responses in even this highly selected group of patients. Presumably changes in tolerance to frustration may arise in relationship to activation of the temporal lobe focus but requires a further interaction with environmental factors to trigger off aggressive responses. These, in turn, evoke a feedback from the environment so that a vicious circle of aggression and counter-aggression is set up which cannot possibly be broken by destruction of the focus alone. Following the operation, therefore, it is necessary to attempt a period of active rehabilitation differing with each patient in which the pathological patterns of reaction can be reexamined and an attempt made to rehabilitate the patient, who may now show basically a lesser degree of irritability and a higher threshold to frustration.

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COMPARISON OF PSYCHOLOGICAL EFFECTS OF DIFFERENT METHODS OF SURGICAL TREATMENT OF EPILEPSY

J. A. L. NAUGHTON and V. M. CAIRNS

Department of Surgical Neurology, Western General Hospital, Edinburgh, Great Britain

INTRODUCTION

Enthusiasm for surgical treatment of epilepsy has varied over the years in accordance with current beliefs, not only about its efficacy in the prevention of further fits, but also about the likelihood of production of undesirable neurological and psychological side effects.

Reports of direct comparison of the psychological effects of different methods of surgical treatment of epilepsy, using objective standardised methods of assessment exist (HOROWITZ ET AL.[2]) but are not frequently encountered. Comparison of reports from different centres is difficult, because not only do the surgical techniques differ, but so also do the psychological.

While it is reasonable, in the present state of our knowledge, to assume greater safety from undesirable side effects with relatively small stereotactic lesions than with more massive cerebral excisions, particularly if bilateral and symmetrical, further examination of this question appeared to be of some value. For this purpose differences in methods of treatment adopted for different cases by different surgeons in the Department of Surgical Neurology in Edinburgh offered the opportunity.

METHOD

Pre- and post-operative psychological examinations were conducted using, as well as ordinary interview methods, formal standardised tests and objective behavioural assessments. This paper is concerned only with the findings on cognitive tests.

Language functions were assessed with the Mill Hill Synonym Selection and Definitions Test (RAVEN[3]), except in one case when the Terman-Merril Oral Definitions Test (TERMAN and MERRILL[5]) was used.

Abstract reasoning was assessed with the Progressive Matrices Test of Raven (RAVEN[4]).

Memorising functions were sampled with a sentence repetition test from the T. M. series (TERMAN and MERRILL[5]) and the Memory-for-Designs Test of Graham and Kendall (GRAHAM and KENDALL[1]). In presentation of results the error score on this last test is reversed in sign to facilitate comparison with the other tests.

SUBJECTS

The subjects of investigation were 30 cases of epilepsy treated by 37 operations. Case characteristics and operation types and sites are given in Table 1. Some differences between groups are evident. "Central" cases were chiefly those with lesions in the thalamus and capsule.

Table 1

Case characteristics and operative groups

	Sex ratio M : F	Age <20	Age >20	Hand pref. R : L	Postoperative interval <1 m.	<6 m.	>6 m.
Excision							
Frontal	3 : 1	2	2	4 : 0	2	1	1
Temporal	5 : 6	3	8	11 : 0	6	3	2
Occipital	1 : 0	1	0	0 : 1	1	0	0
Coagulation							
Amygdala	5 : 1	2	4	6 : 0	1	1	4
'Central'	5 : 2	1	6	6 : 1	5	1	1
Amygd. + 'central'	0 : 1	0	1	1 : 0	0	1	0
Total	19 : 11	9	21	28 : 2	15	7	8

Note: 'Central' comprises chiefly thalamic and capsular lesions.

Table 2

Fits

Operation	Major fits Daily	Weekly	Monthly	Ratio Major/other
Excision				
Frontal	0	2	0	2 : 2
Temporal	1	3	1	5 : 6
Occipital	0	0	0	0 : 1
Coagulation				
Amygdala	0	2	0	2 : 4
'Central'	3	2	0	5 : 2
Amygd. + 'central'	0	0	0	0 : 1
Total	4	9	1	14 : 16

Table 3

Occupation

Operation	Open Regular	Occas.	H'wife	School	Shelter.	None	Total
Excision							
Frontal	1	2		1			4
Temporal	4		3	2		2	11
Occipital				1			1
Coagulation							
Amygdala	2	3				1	6
'Central'		3			1	3	7
Amygd. + 'central'			1				1
Total	7	8	4	4	1	6	30

Table 4

Pre-operative level

	Vocabulary		Progressive Matrices		Memorising			
	>50th %ile	<50th %ile	>50th %ile	<50th %ile	Verbal		Designs	
Excision					+	—	+	—
Frontal	0	3	0	3	0	4	3	1
Temporal	2	9	2	8	4	7	8	3
Occipital	0	1	0	1	—	—	0	1
All excis.	2	13	2	12	4	11	11	5
Coagulation								
Amygdala	3	4	3	3	3	3	4	2
'Central'	0	7	0	7	1	6	2	5
Amygd. + 'central'	0	1	0	1	0	1	1	0
Total	5	25	5	23	8	21	18	12

All cases had suffered from fits for several, usually many, years, which had proved refractory to medical control (Table 2). The majority showed more or less serious social or occupational repercussions (Table 3). Pre-operative cognitive deficits were common (Table 4). In most cases there was a significant reduction in fit frequency during the period of post-operative observation. All cases received medication before and after surgery.

(Neurological and psychiatric findings are in course of study by our colleagues).

Table 5

Mean postoperative test changes

	N	Vocabulary Mill Hill	Progressive Matrices	Sentence repetition	Graham-Kendall
Excision					
All frontal	4	+5.75	+2.3	+/0	+1.7
R. temporal	5	+0.33	+2	0	+2
L. temporal	6	−1.8	+4.6	0	+1.5
L. occipital	1	0	−2	—	−4
Coagulation, stereotactic					
R. amyg.	2	0	+7	0/−	−0.5
R. + L. amygdala	4	−0.33	+2.9	0	+2.3
R. + L. 'central' 2 session	13	−0.5	−1.3	0	+0.7
1 session	1	−50	−29	—	−28
Amyg. + 'central'	1	−8	−10		−3
All	37	−0.17	−1.8	0	+0.28

RESULTS

These are presented in Table 5. Changes between pre- and post-operative test performance are rarely large. Some trends, however, appear, viz.:

1. In contrast to the tendency to improvement in the other groups there is a tendency to decline on the test of language function in left temporal excisions, "central" lesions, and one-session bilateral amygdalotomy.

2. There is a general tendency to decline in test performance in the few cases of one-session bilateral "central" lesions.

Comparing unilateral cerebral excisions with bilateral amygdalotomies, no general difference in post-operative psychological test performance is evident.

No test change is noticeable in cases of frontal and right temporal excisions, apart from some post-operative improvement, nor in right-sided amygdalotomy, except for slight post-operative improvement on the reasoning test.

In the cases in whom more prolonged follow-up was possible (Table 6), it was noticeable that, while a decline in the abstract reasoning test tended toward recovery to the pre-operative level, this was not so evident with other types of deficit.

Table 6

Correlation between improvement in score and length of follow-up

Test	Correlation coefficient (Spearman Rho)
Progressive Matrices	0.56 (Signif.)
Mill Hill Vocabulary	0.02 (N.S.)
Graham-Kendall	0.04 (N.S.)

DISCUSSION

Comparison of the effects of the different types of operative procedure on psychological test performance is complicated by differences between the groups of cases which could be related to these effects, viz.:

1. Variation in numbers and sites of lesions. The majority of stereotactic amygdaloid and "central" lesions were double and bilateral. Most of the double amygdaloid lesions were produced at one operative session, while most of the second "central" lesions were after a greater interval. Only one partial lobar excision was double and bilateral, a frontal case, while all the rest were unilateral.

2. Variations in pre-operative clinical state. In general fits were more severe in the cases of "central" lesions than in those of amygdalotomy or cerebral excision. Pre-operative cognitive test function was also generally poorer.

3. Variation in interval before post-operative assessment. In the cases of two-session bilateral "central" procedures the period is limited by the timing of the second operation. It is also affected by accessibility for formal assessment.

Bearing these considerations in mind one might tentatively hypothesise that bilateral amygdalotomy is a safer procedure as regards unwanted psychological effects than the other bilateral "central" operations in this series, but require further confirmation of this from series more comparable in pre-operative clinical state. Selection for different types of operation might make this difficult to achieve.

Comparing bilateral stereotactic lesions with unilateral cerebral excisions, which is hardly fair scientifically but perhaps not unreasonable for some clinical purposes, the differences in these cognitive tests are not noticeable.

CONCLUSIONS

Risks of production of cognitive deficits by unilateral partial temporal lobectomy, or bilateral stereotactic amygdalotomy are small, so far as this system of assessment demonstrates. Risks are rather higher in bilateral "central" lesions in patients showing appreciable pre-operative deficits.

Minor deficits in language functions are as likely with left-sided "central" as temporal lesions.

In the majority of cases such changes as were observed were minor, and rarely of importance in the patient's life in comparison with the effects of chronic intractable epilepsy.

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Surgical Treatment of Epilepsy: Evaluation of Psychological Effects

V.M. CAIRNS and J.A.L. NAUGHTON
Department of Surgical Neurology, Western General Hospital, Edinburgh, Scotland

Surgical treatment of epilepsy has been employed since at least the time of Victor Horsley (Horsley 1890). Its indications and probable benefit have been well worked out in particular types of case, e.g. by Murray Falconer (Falconer 1972).

It is clear that in practice various forms of selection, explicit or implicit, are employed by doctors who refer patients with epilepsy to hospital in general, and to neurosurgeons in particular, prior to the further selection for operative treatment.

This may result in considerable primary differences between cases referred for specialist advice and those not; between cases treated by surgery and those not; and between cases treated in different surgical centres, quite apart from the further differences arising from the use of different selection criteria for treatment.

From the literature it appears that Penfield regards both mental defect and psychiatric disturbance as contra-indications since his series of patients includes only a small percentage of both (Bengzon *et al.* 1968). Falconer and Taylor (1970) regard serious mental defect as a contra-indication but 87 patients in one series of 100 patients were psychiatrically disturbed pre-operatively. Green and Scheetz (1964) state that neither mental defect nor psychiatric disturbance should be regarded as contra-indications. These neurosurgeons all insist on either definite clinical evidence of psychomotor seizures or EEG evidence or both, whereas for others (Narabayashi *et al.* 1965; Heimburger *et al.* 1968; Vaernet and Madsen 1971) violent, destructive or overactive behaviour may be the criterion for selection for surgery in the presence or absence of direct evidence of epilepsy.

Evaluation of the results of treatment must therefore be related to the individual characteristics of the types of cases treated.

With these considerations in mind we have examined some of the psychological characteristics of patients referred to this unit for investigation of epilepsy other than symptomatic. We then compared the subgroup for whom neurosurgical treatment was undertaken with the rest, as well as with their postoperative state.

Investigation

Subjects: The series consisted of 352 patients all of whom were examined personally by one or other author. Of these 69 received operative treatment. This is 20 per cent of our sample, which is comparable with a figure of 19.5 per cent obtained by Currie *et al.* (1971) in a series of cases of temporal lobe epilepsy but much greater than that expected in a group of all types of epilepsy. Williams (1969) estimates not more than 0.5 per cent of patients with epilepsy are likely to come to surgery.

Sex distribution is given in Figure 1. This shows that twice as many males as females received operative treatment, while the ratio in the non-operated group was about 1.5 to 1. Analysis of age distribution revealed that 90 per cent of operations were performed on cases below 40 years of age, although these represented only 69 per cent of referred cases.

Methods of investigation: A selection was made of the non-operated cases, matching them with the operated on the basis of age at examination, age at onset of epilepsy, and sex.

These were then compared in cognitive function, using the Progressive Matrices (Raven 1960) or the Revised Stanford-Binet Intelligence Scale (Terman and Merrill 1961) in cases too young or dull for the

Matrices to be appropriate. Other tests included the Mill Hill Synonyms Selection and Definition Test, the Graham Kendall Memory for Designs Test and a Sentence Repetition Test (based on the Stanford-Binet 11 year item). Behavioural assessments were made using rating scales, and personality assessments using questionnaires, but these will not be reported here.

Further postoperative examinations were then made of the cases receiving surgical treatment.

Results

Table 1 shows a progressive reduction in above-average scores on intellectual tasks, from unmatched to matched non-operated to cases selected for operation, and a converse increase in below-average ones.

Table 2 shows that most cases with onset of epilepsy below 10 years came in a dull to lower intellectual category. This did not apply to cases with onset later than 10 years, although they did show a preponderance of the lower psychometric levels compared with a normal distribution of scores.

For the operative group the pattern on vocabulary is similar to that on non-verbal reasoning, i.e. a very high proportion with onset in the first decade falling in the below average category, whereas only 35 per cent of those with onset over 21 obtain below average scores.

The matched non-operated group shows a rather better performance on vocabulary with 45 per cent being below 25th percentile for normal groups where onset was in the first decade and only 25 per cent (the expected proportion) below this level where onset was over 21.

Comparisons of performance on memorising tasks with age of onset of epilepsy classified in decades are presented in Table 2.

On design reproduction, non-operated with later onset performed more poorly than operated cases, as they also did on rote sentence repetition; whereas for early onset there was little difference between operated and non-operated groups on design reproduction, but a higher percentage of non-operated cases was successful on rote sentence repetition.

The total group shows no appreciable differences on the non-verbal memorising tasks, but again relative lack of above-average vocabulary scores and a tendency to poorer rote verbal memory.

An analysis of operated cases by type of operation, age of onset, sex ratio and age at operation is shown in Table 3. It shows that within the general tendency for operative treatment to be used for the cases of earlier onset this is less marked for "central" and more marked in the amygdalotomy group. It also shows that within the general tendency for many more males than females to receive operative treatment the ratio is much nearer equality in the cases of temporal lobectomy.

No "central" lesions were made in cases under 11 years and only 22 per cent were under 20 years in contrast to the other types of operation in which about 40 per cent were under 20 years.

An analysis of operated cases, by type of operation and pre-operative intellectual levels is presented in Table 4. This shows a general tendency for the distribution of test scores to be skewed toward the lower levels pre-operatively for all three groups, this being rather more marked in the right temporal lobectomy group and slightly more so in the "central" group than in the amygdalotomy and left temporal lobectomy groups.

Pre- and post-operative psychometric changes in operated cases and analysis by type of operation are given in Table 5. Little change is evident apart from slight improvement, probably practice effects, in other than "central" lesions.

On non-verbal reasoning 10 of the 12 amygdalotomy cases assessed showed postoperative increase. In the "central" group, four cases showed an increase in score postoperatively and five cases a decline. The overall mean in this group showed a decline postoperatively.

No consistent trends are noted on other tests for any of the main operative groups, the mean change in score often being largely weighted by one or two cases in the group showing a marked change.

Length of follow-up for the three main operative groups is shown in Figure 2. In a previous study (Naughton and Cairns, in press) our follow-up interval was less than one month in half of the cases. In the present study the follow-up interval was greater than one month in 80 per cent of the cases and greater than six months in 63 per cent of cases. In our shorter follow-up study we reported a high correlation between length of follow-up and recovery of scores on non-verbal reasoning. No such trend is observed in the present study. There would however appear to be a relationship between longer follow-up and decrease in vocabulary scores, and in design reproduction, most marked in the "central" group.

Age of onset		Raven's Progressive Matrices			Mill Hill Vocabulary Scale		
		Above average > 75th %ile	Average (25th – 74th %ile)	Below average < 24th %ile	Above average > 75th %ile	Average (25th – 74th %ile)	Below average < 24th %ile
0-10	"Operated" cases (33)	3	12	85	0	15	84
	Non-operated cases (52)	3.4	24.2	72.4	13.8	40	45.6
11-20	"Operated" cases (14)	0	57.2	42.8	0	50	50
	Non-operated cases (22)	10	55	35	15.9	46.9	36.9
21 +	"Operated" cases (8)	12.5	50	37.5	0	62.5	37.5
	Non-operated cases (12)	25	39.3	35.7	33.4	41.7	24.9
	Total operated cases (55)	3.6	29.1	67.3	0	30.6	69.4
	Total non-operated cases (86)	10.9	3.4	55	16.8	42.4	40.8

Table 2: Percentage distribution of test scores, by age of onset

Age of onset		Graham Kendall Memory for Designs				Sentence Repetition			
		0-4 Normal	5-11 Borderline impairment	12+ Organic impairment	Not testable	Pass	(√) Borderline	Fail	Not testable
0-10	"Operated" cases (33)	33	21.9	19.8	27.9	12	6	48	33
	Non-operated cases (52)	41.8	26	15.2	17	33	6.4	46.7	14
11-20	"Operated" cases (14)	63.9	21.3	14.2	0	23	15.3	61.7	0
	Non-operated cases (22)	58.8	27.4	13.8	0	33.3	11.1	55.5	0
21+	"Operated" cases (8)	62.5	37.5	0	0	62.5	0	37.5	0
	Non-operated cases (12)	42.9	28.5	28.5	0	53.8	0	46.2	0
	Total operated cases (55)	45.4	23.7	14.6	16.3	22.2	7.4	50	20.4
	Total non-operated cases (86)	46.3	26.8	17	9.7	32.8	6.3	46.8	14

Table 2b: Percentage distribution of test scores, by age of onset

		Age of onset			Sex ratio		Age	
		0-10	11-20	21+	Male	Female	Mean	Range
Stereotactic procedures	1. Central lesions (9)	44%	33%	22%	77.5%	22.5%	28.8	13-42
	2. Amygdalotomy (17)	59.7%	13.5%	26.7%	76%	24%	25.5	6-44
Excisions	3. Temporal lobe	62.5%	25%	12.5%				
	(right) (10)				55%	45%	24.2	7-52
	4. Temporal lobe	40%	40%	20%				
	(left) (10)							
	5. Gyrectomy (2)		100%			100%	23.5	20-27
	6. Limbic system (3)	100%			100%		14	8-28
	7. Other (7)	42.8%	57.2%		71.5%	28.5%	21	11-37
8. Craniotomy (5)		75%		25%	40%	60%	26	18-39
9. Shunts (3)		100%			100%		11	5-17
Total "operated" cases (66)		58.4%	28%	16.6%	66.6%	33.3%		

Table 3: Age of onset, sex ratio, and age for different types of operation

Type of operation	Test scores		
	Above average	Average (25th - 74th %ile)	Below average
1. Central lesions	0%	33.3%	66.6%
(9)		(3)	(6)
2. Amygdalotomy	6%	35%	59%
(17)	(1)	(6)	(10)
3. Temporal lobe excisions			
(a) Right	0%	16%	84%
(7)		(1)	(6)
(b) Left	11%	33%	56%
(9)	(1)	(3)	(5)
4. Limbic lesions	0%	33.3%	66.6%
(3)		(1)	(2)
5. Other excisions	17%	50%	33%
(6)	(1)	(3)	(2)
6. Craniotomies	20%	40%	40%
(5)	(1)	(2)	(2)
7. Shunts			100%
(3)			(3)

Table 4: Pre-operative intellectual level for different operative groups (Raven's Progressive Matrices, or Stanford-Binet)

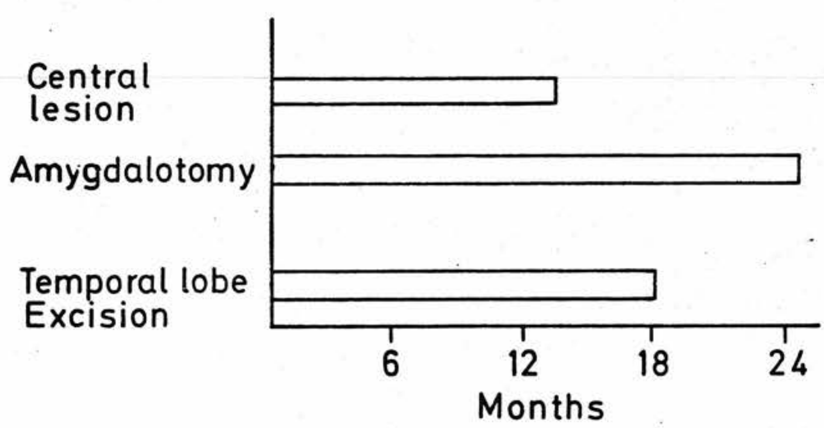

Figure 2: Mean length of follow-up for main operative groups

Operative procedure	Raven's Progressive Matrices				Mill Hill Vocabulary Scale				Graham Kendall Memory for Designs				Sentence Repetition		
	Mean change in score	No. +	No. –	No. same	Mean change in score	No. +	No. –	No. same	Mean change in score	No. +	No. –	No. same	No. +	No. –	No. same
1. "Central" lesions															
a. Unilateral (right) (4)	+0.5	2	2	0	+0.5	3	1	0	–5.2	2	2	0	0	2	2
b. Bilateral (5)	–3	3	2	0	–10.6	3	2	0	0	2	3	0	2	0	3
Total (9)	–1.5	5	4	0	–5.8	6	3	0	–3	4	5	0	2	2	5
2. Amygdalotomies															
a. Unilateral (right) (3)	+5	3	0	0	+1.6	1	0	2	–1.7	1	2	0	0	1	2
b. Bilateral (10)	+3.1	7	2	0	+1.7	5	4	0	+1.7	6	2	1	2	2	6
Total (13)	+3.5	10	2	0	+1.7	6	4	2	+0.7	7	4	1	2	3	8
3. Temporal lobe excisions															
a. Unilateral (right) (4)	–0.75	2	1	1	+0.3	1	0	2	+2.7	2	1	0	1	0	2
b. Unilateral (left) (8)	+3.4	5	2	1	–0.6	4	5	0	–1	2	3	4	1	2	6
Total (12)	+2	7	3	2	–0.4	5	5	2	+0.8	4	4	4	2	2	8

Table 5: Comparison of pre- and post-operative results for three main groups

Discussion and Conclusions

Sex ratio, age at referral, age of onset of epilepsy and age at operation: Since the ratio of male to female in cases of epilepsy treated in general practice is about 1.5 : 1.3 (The Medical Care of Epilepsy in Scotland, 1968) it appears that males are more likely to be referred for hospital investigation, and even more likely to receive operative treatment than females, except in those cases receiving temporal lobectomy. The reasons for this are speculative. A general male tendency to more violent behaviour, as shown in delinquency and accidental injury figures, aggravated by epilepsy and leading to difficulties in management, appears possible: the greater importance to the male of economic competitiveness may also be a factor in older cases.

Males may also be more subject to pre-, peri-, and neo-natal adverse influences leading to epilepsy of early onset which is more difficult to control than that of later onset.

In a series of 208 cases of cerebral palsy 60.5 per cent were male and 39.5 per cent female overall (Ingram 1964), i.e. almost exactly the same ratio as in the present series. The excess of males was most marked in patients with hemiplegia, who also constituted the group with the highest incidence of grand mal and Jacksonian epilepsy. This may therefore be the link accounting for the importance of maleness and youth in selection for operative treatment.

Intelligence test performance, age at onset of epilepsy, and age at operative treatment: It is important in comparing the results of medical with surgical management of epilepsy that age distribution of cases be considered since prospects with cases of later onset are probably generally better (Currie *et al.* 1971).

The findings confirm those of other authors (Pond 1961; Rodin 1968: Falconer 1970) that early onset of epilepsy tends to be associated with poor cognitive test performance. This may in turn tend to be associated with behaviour disorder of the type whose difficulty of management may lead to earlier referral for surgical treatment. Relief or remission of fits has been reported to lead to improvement in psychological function (Chaudry and Pond 1961) but so far our observations are insufficient to permit comment on this, except to note that it has occurred in a few individual cases but not in the majority over our period of observation.

It also appears possible that doctors are more willing to refer cases for surgical treatment in whom impaired function is already noticeable, and the risk of further loss from operative misadventure may appear a less serious matter.

The chief qualitative cognitive feature distinguishing the group chosen for operation appears to be the relatively poor rote verbal memory of the cases with onset of epilepsy below 20 years, which might well reflect a continuing subclinical epileptiform process interfering with the psychological functions grouped as "attention" and "registration". Pond, after expressing some scepticism about the existence of such processes, later accepted their probability (Pond 1961).

It does appear that frequent fits during childhood have a stultifying effect which is not so frequently found in cases with later onset.

Type of operation, age of onset of epilepsy, and sex ratio: It appears likely that choice of operation will be related to type of epilepsy and behavioural repercussions. This probably explains the preference of operation on the amygdaloid nuclei for younger cases who show more violent behaviour, and on "central" brain stem structures for the cases in whom the frequency of fits is itself the major behavioural feature and who are generally older.

It is not clear why there should be a relative preference for temporal lobectomy in female cases, unless perhaps a relative lack of violently aggressive behaviour in the patients leads to less attack on the mygdaloid nuclei.

Type of operation and test changes: The small postoperative improvement on tests of cognitive function noted in both the amygdalotomy and temporal lobe excision groups is lacking in the "central" group. This appears most readily explicable as impairment of alertness, concentration and energy, from lesions in activating brain stem systems. This may perhaps be related to the relatively greater age of this group of patients, as well as to site of operation. Selective deterioration in the older subjects after frontal topectomy has been reported by Smith and Kinder (1959).

Since frequent fits may also do this, and possibly also long-continued heavy medication, the choice of patient and surgeon is not easy.

Summary

Findings are presented for 352 patients suffering from epilepsy, 69 of whom received operative treatment, in respect of age at referral, age at onset of epilepsy, sex ratio, type of operation, and cognitive function, before and after operation.

In general, cases selected for operation showed a higher proportion of males, earlier referral for treatment, and poorer cognitive test function, than other cases.

Possible explanations of this are discussed.

Postoperative cognitive test changes were relatively small and insignificant, but there was slightly more tendency to impairment after bilateral "central" lesions than after other types of operation, possibly because the cases tended to be older than the other groups, and/or more vulnerable to lesions in "activating" systems.

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CHAPTER 22

Observations on the development of an assessment scheme for amygdalotomy

E R HITCHCOCK, G W ASHCROFT,
V M CAIRNS & L G MURRAY

INTRODUCTION

It is obvious that psychosurgery has become the focus of growing attention and increasing scrutiny. Recent adverse criticism can be refuted only by objective evidence of the results of psychosurgical procedures. Early assessments of psychosurgery were admirable surveys and analyses including both operative, psychological and psychiatric data (Partridge, 1950; Petrie, 1952). It is unfortunate that subsequent studies have not been so detailed nor so objective. A complete assessment of any psychosurgical procedure can only be made with information about psychiatric, psychological and surgical events; and to be relevant each must be related to the other so that the surgical procedure is only carried out on patients who have had complete preoperative assessments, thus enabling comparison to be made with postoperative results of similar cases earlier in the series. Similarly, the effects of psychosurgical lesions on psychological and psychiatric performances on testing must be related to an exact siting of the target and the extent of the surgical ablation.

The type of patient likely to be referred for psychosurgery, especially those referred for the treatment of aggression, is particularly resistant to most conventional methods of assessment. Psychological testing is extremely difficult since the absence of co-operation and motivation is usually a contributory reason for referral.

This necessitates the use of objective measurements of patient behaviour which make no demands on the patient's co-operation and can provide quantitative assessments even in the most unco-operative patient.

At the last conference we reported on a pilot study assessing patients submitted to amygdalotomy (Hitchcock, Ashcroft, Cairns & Murray, 1972). We have adhered as closely as possible to the assessment scheme described, with pre- and postoperative psychological and psychiatric assessment, including a one-month pre- and postoperative period of inpatient psychiatric hospitalization in the ward of the Brain Metabolism Unit.

In this paper we present some of our findings during the development of a comprehensive scheme of assessment. The first few patients in the series were treated with only sketchy pre- and postoperative assessments. More recent follow-up studies of some of these early cases have utilized the more comprehensive assessment procedures now available. We wish to report our results to date for all our cases.

We will also mention briefly some of the more recent extensions as the amygdalotomy project has developed from an isolated surgical project into a multidisciplinary team approach, with benefit to all participants.

PATIENTS

Our attempts to evaluate the effectiveness of amygdalotomy in a group of 17 patients over the past 5 years with increasingly detailed pre- and postoperative assessments of behaviour have emphasized the complexity of factors contributing to behaviour and the difficulty of evaluating the degree of change produced by surgical intervention.

All patients were referred from either neurologists or psychiatrists. Unfortunately, because of his association with the project our assessing

14 AMYGDALOTOMY CASES

	Pre - op	Post - op
At Home	10	9
Hospitalised	4	5
Total	14	14

OCCUPATION

		Pre - op	Post - op
Open Employment	Regular	2	2
	Occasional	2	3
Sheltered Occupation		2	4
No Occupational Activity		8	5
Total		14	14

Figure 22.1 Domicile and occupation.

psychiatrist is unable to refer patients personally in that such a referral would obviously influence his assessment and possibly his staff's ratings. A number of patients referred have come from other sources therefore, largely from neurologists, although over the past few years there has been an increasing referral from a large neighbouring mental hospital. This expansion of the project has been most interesting and we have been able to have discussions and exploration of views of clinicians who are not themselves directly involved in the project but who have referred patients for amygdalotomy. Although at first such participation and discussion was treated with some reserve since it might influence assessment and control studies, in practice it increased the accuracy of assessment by permitting a longer period of pre- and postoperative observation, so that we are now in many cases able to have an assessment in the referring hospital, an immediate preoperative assessment of one month in the special unit, an assessment during admission for the surgical procedures, and a postoperative assessment in the special unit, after which the patient returns to the referring hospital. A strong history of aggression was obtained in all cases. Many of these patients in whom the prime reason for referral was that of aggression, had associated personality disorders.

As far as occupational activity is concerned, three patients previously incapable of any form of occupational activity are now either employed or attending industrial therapy units (Figure 22.1).

The ages of the patients ranged from 8–44 years. Intellectual level was low in the majority of cases (Figure 22.2).

There were twelve males to five females, a male predominance of more than 2 : 1, and in keeping with other series. This high incidence of male aggressivity is interesting although relevant only to the selected patients and it does not necessarily bear a relationship to the population as a whole. Thirteen of the 17 patients were epileptics and in one case there was a past history of a mild epilepsy.

One patient had episodic impulsive automatic behaviour which might be regarded as epileptic phenomena but on no occasion was any epileptic activity demonstrated by electroencephalography nor was there any past history of epilepsy, although there was a family history of temporal epilepsy in a sibling. The association between impulsive behaviour and epileptic phenomena is an unresolved problem and further study has yet to be made in these cases.

NEUROSURGICAL STUDIES

Although the opportunity for chronic electrode studies rarely arose, such investigations were done whenever possible and when the indications appeared correct for the patient's management. The value of chronic electrode studies is difficult to assess and our own experience in this project has been limited. We have inserted electrodes into the amygdala, and in five patients, into the hippocampus bilaterally.

When the patients were admitted to the neurosurgical wards they were investigated by routine neurosurgical investigations such as straight skull

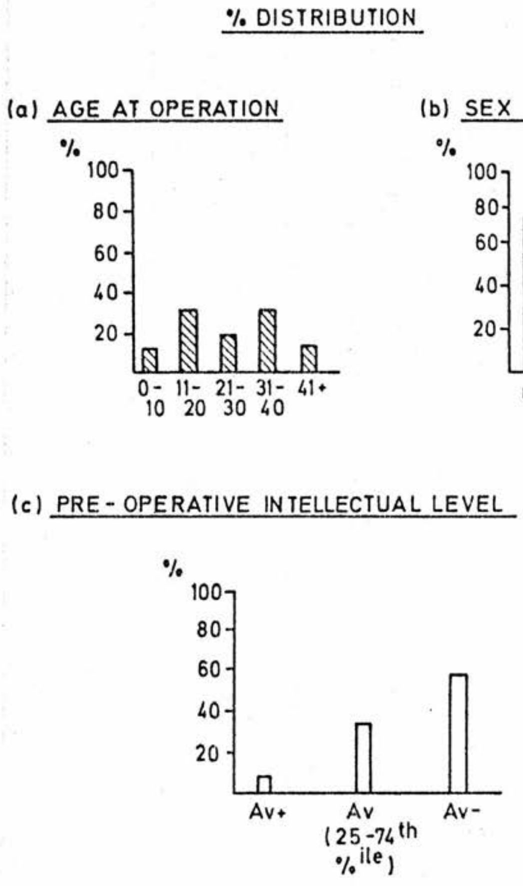

Figure 22.2 Age distribution, sex ratio and preoperative intellectual level.

x-ray, cerebral isotope scan and air encephalography. Although no tumours or other space-occupying lesions were revealed in any of the patients, in a few cases it was helpful in indicating ventricular enlargement and temporal lobe distortion.

The early approaches to the amygdala were transfrontal, the electrode traversing other parts of the brain than the temporal lobe. Although the possible damage must be small, to eliminate any possibility of damage to such structures influencing the assessment of patients, the direct transtemporal approach has been used for all but the first two or three cases. A further advantage of this approach has been a shorter brain track and an opportunity to record and stimulate en route to the amygdala. The first few cases were treated using the Leksell stereotactic system but the direct temporal approach was not possible with this instrument. Therefore, all other cases were treated

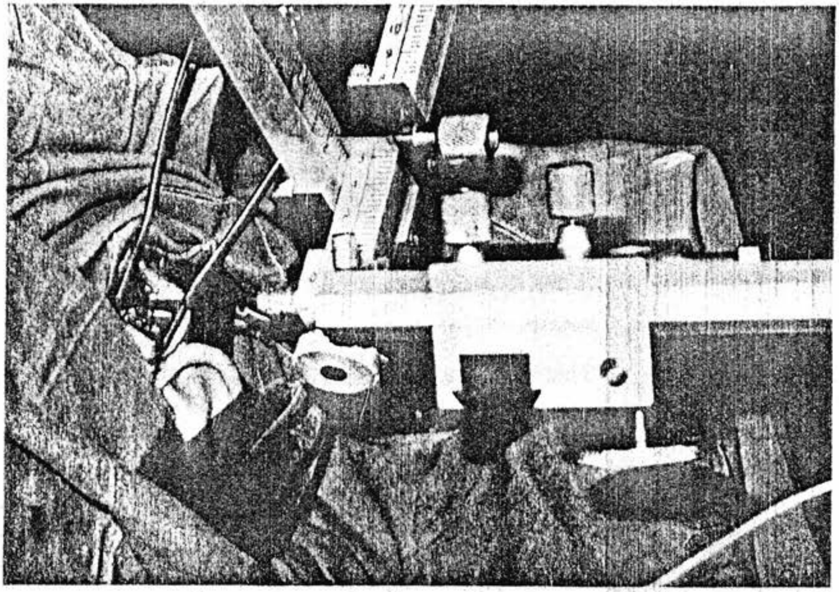

Figure 22.3 Transtemporal insertion of electrode using the direct attachment.

using a different stereotactic system (Hitchcock), which permitted the transtemporal approach (Figure 22.3, 4).

A total of 19 operations have been carried out. In one case no lesion was made owing to a deterioration in the patient's condition following application of the stereotactic frame and making a burr hole. This patient will not be analysed here. One patient had contralateral amygdalotomy 3 years after the first lesion. Two patients had unilateral lesions only and the remaining 14 had bilateral one-stage operations. In one of them surgery was too recent for any follow-up data to be included.

Whenever possible, procedures were performed without premedication under local anaesthesia. Nine patients were operated on under local anaesthesia and one was anaesthetized for the preliminary stereotactic procedure and when the probe was inserted the patient was allowed to waken up. The remaining eight patients had bilateral amygdalotomy performed under general anaesthesia because of their aggressive behaviour, and were considered too disturbed to undergo the procedure under local anaesthesia. Even those who were considered suitable for local anaesthesia often behaved violently during stimulation of temporal lobe structures, disturbing the sterile environment and trying to tear the stereotactic instrument from their heads. Five of the 17 patients showed extreme restlessness and disturbed behaviour during the procedures. As aids to checking the accuracy of electrode placement, steel ball markers were usually inserted at the sites of the lesions for subsequent radiological verification. Although in the postoperation period some patients were so disturbed that they removed their dressings and fingered their

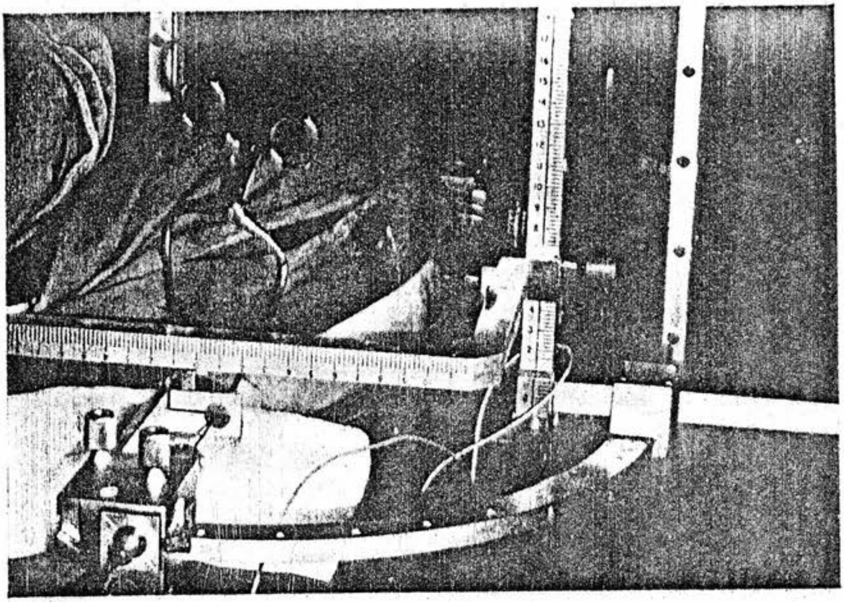

Figure 22.4 Transtemporal insertion of electrode using the quadrant arc.

wounds, postoperative infections were minimal and no serious infection arose.

BIOCHEMICAL AND PHYSIOLOGICAL STUDIES

Because of the close association of the amygdala with the hypothalamus and its influence on the endocrine system it is hardly surprising that hormonal disturbances were manifest postoperatively in some patients, the most impressive being a patient who developed acute and severe gynaecomastia. The project has broadened therefore to include a biochemical study performing hormonal assay, examining the continuous urinary testosterone excretion pre- and postoperatively. Although originally it was hoped to include all patients in this particular study, the variation in urinary excretion in females was such that this test was considered unreliable, and at the present time the estimations have been done on male patients only.

Biochemical analyses in the pre- and postoperative periods have been confined to CSF concentrations of amines. The amygdala is rich in 5HT and if this contributes to the 5HIAA metabolite levels of CSF one could expect to see changes in the CSF concentration of 5HIAA postoperatively.

Because bilateral amygdalotomy in primates is said to alter the facility to habituate neural responses to repeated external stimuli, a standard habituation method has been developed by the special unit to determine the habituation of the skin conductance response to repeated auditory stimuli. The habituation of other arousal responses such as skin vasoconstriction, heart rate changes and blocking of alpha EEG rhythm are also recorded routinely, but measurement and interpretation of these results present problems and analysis has been difficult. Despite the association of all members of the team and an attempt to control the medication, the difficulties of management of these patients in terms of their aggression and/or epilepsy are such that many of these studies have been spoiled by the sedative effects of medication or non-standardized drug regimes pre- and postoperatively.

PSYCHIATRIC AND PSYCHOLOGICAL STUDIES

Over the years our experience has shown that control situations are almost impossible to achieve, may be undesirable, and in themselves by producing a stress situation, affect assessment ratings. Eventually by discussion and experience a compromise situation has been reached where a known environment is used for pre- and postoperative assessment and where medication is stabilized as much as possible.

The psychiatric assessment comprises preliminary outpatient interview by a consultant psychiatrist, and the patient is then admitted for a month's inpatient preoperative assessment in the special unit at a time dictated by the operation date previously arranged. The admission to the special unit enables a fuller psychiatric assessment in the relatively controlled setting. The patient is continuously rated by trained nursing staff with the Hargreaves Nursing Rating Scale (28 behavioural items) (Hargreaves, 1968), providing daily ratings during the immediate pre- and postoperative inpatient psychiatric observation. However, it has not been applicable to all cases, and we have found that The Adaptive Behaviour Scale (Nihira, Foster, Shellhaas & Leland, 1969) enables a more general assessment to be made by a wider range of raters, is much less time-consuming, and is useful in obtaining information about the patients living at home. Neither of these scales is ideal for every case in our series, but we have very few instances where the scales were not felt to provide the relevant information. The Hargreaves scale was designed for use with acute psychiatric cases. The Adaptive Behaviour Scale was designed for use with institutionalized retardates. However, within the standardization population level of intelligence was not a significant factor in relation to degree of maladaptive behaviour. Our cases include a large proportion at the lower end of the intellectual scale. We have now made use of the scale in 11 cases, obtaining pre- and postoperative ratings in eight cases, and postoperative ratings only, in three cases. Relatives have sometimes been asked to complete ratings, either as the sole means of assessment available or in addition to ratings made by staff in hospital and industrial therapy units (Figures 22.5,6).

The data for violent and destructive behaviour indicate that of the four male cases on whom pre- and postoperative ratings were made, three showed a substantial drop (two to zero). Postoperatively one of these has a follow-up of 5 years. One of these four with a moderately high preoperative level showed no substantial improvement. Of the four female cases (all were preoperatively more violent than 90% of an equivalent population) only one showed marked improvement. This is the only female case living at home and is also the one

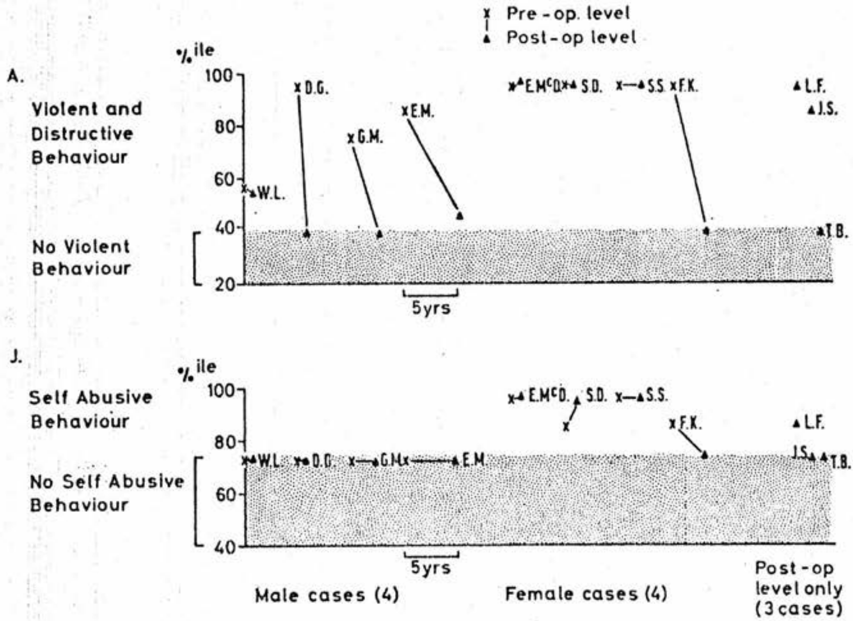

Figure 22.5 Adaptive behaviour scale.

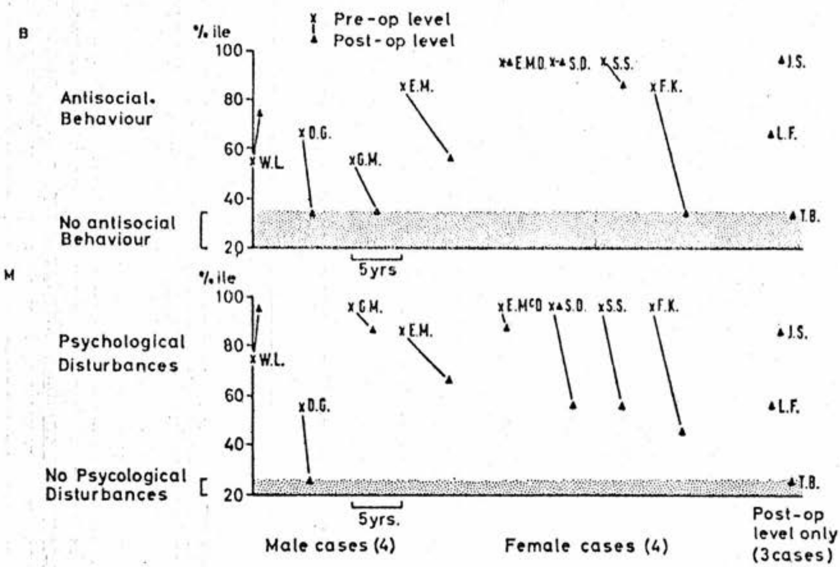

Figure 22.6 Adaptive behaviour scale.

with the longest follow-up (3 years). Four patients showed zero violent and destructive behaviour at the time of the most recent follow-up but five showed a postoperative level of violence higher than 80% of the population.

It is of interest that all four females but only one of the seven males showed any self-abusive behaviour. This behaviour was modified in only one patient postoperatively (the female who also showed a substantial drop in violent behaviour). The cases showing self-abusive behaviour pre- or postoperatively were the cases who also showed the highest level of violent behaviour postoperatively. Antisocial behaviour follows a similar pattern to that noted for violent behaviour, except in one male case where there was a postoperative increase. A range of behaviour such as reaction to frustration, mood changes and hypochondrical tendencies are covered in the area labelled psychological disturbances. All cases showed some degree of such disturbance preoperatively and nine cases postoperatively. Six cases showed a decrease (improvement) postoperatively, one an increase in level and one no real change. Three of the four cases showing greatest overall improvement could be described as having adolescent problems preoperatively and in the fourth there was a change in domestic circumstances.

At the 2nd International Conference on Psychosurgery in Copenhagen, Ursin (unpublished discussion) emphasized the fact that the most objective assessments of behaviour were obtained when the patient's behaviour in a standard situation was observed. This encouraged us to continue the efforts we had already been making to devise such situations. While it is too early to be able to report on pre- and postoperative changes in behaviour in these situations, we would like to mention three such measures which we are now using.

The first is a task designed to provide a measure of tolerance of frustration. The patient is required to draw around a number of different designs by looking at the mirror image of the paper on which he is drawing. The results are quantified in terms of the length of time spent on the task and the number of items attempted.

The second is a tracking task using a pursuit rotor. The patient has a number of trial runs at different speeds. He is then encouraged to adjust the speed himself (providing a measure of choice of level of difficulty). Next, the speed is fixed at a moderate rate, and the buzzer (providing feedback) switched off. A series of false 'success' readings are given, followed by a series of 'failure' readings. This is alternated for dominant/non-dominant hand and for several different patterns and provides a differential measure of the patient's persistence when succeeding and failing.

The Third method is a modification of the Gibson Spiral Maze (Gibson, 1965) in which the patient is required to trace a path through this circular maze, using his non-dominant hand. The test is administered under three conditions. First, the patient is left alone to complete the task; then the patient is stressed every 15 s to increase his speed; and lastly, the patient is stressed every 15 s to increase his accuracy. Variation in time taken and number of errors provide a measure of reaction to a mildly stressful situation.

The aim of these three techniques is to put the patient in mildly frustrating or stressful situations. It was not considered desirable to create situations of a severely stressful nature as it was felt that this would have immediate repercussions in terms of patient management, and would also be likely to preclude any further co-operation in future testing. Hence the variable in the first two techniques is the time spent prior to the patient's decision to terminate the task. It is emphasized to the patient, both before and at fixed intervals during the task, that *he* decides when to stop.

Preliminary results indicate that there is a relationship between levels obtained on the Adaptive Behaviour Scale and other ratings and performance on tasks of a frustrating nature. Much further work is required in terms of obtaining normative data before the value of these techniques is established.

Where possible standard methods of personality assessment are also used. However, most personality questionnaires are of limited application in view of the low intellectual level of many patients.

RESULTS OF AMYGDALOTOMY

The 16 Personality Factor Questionnaire (Cattell, Eber & Tatsuoka, 1970)

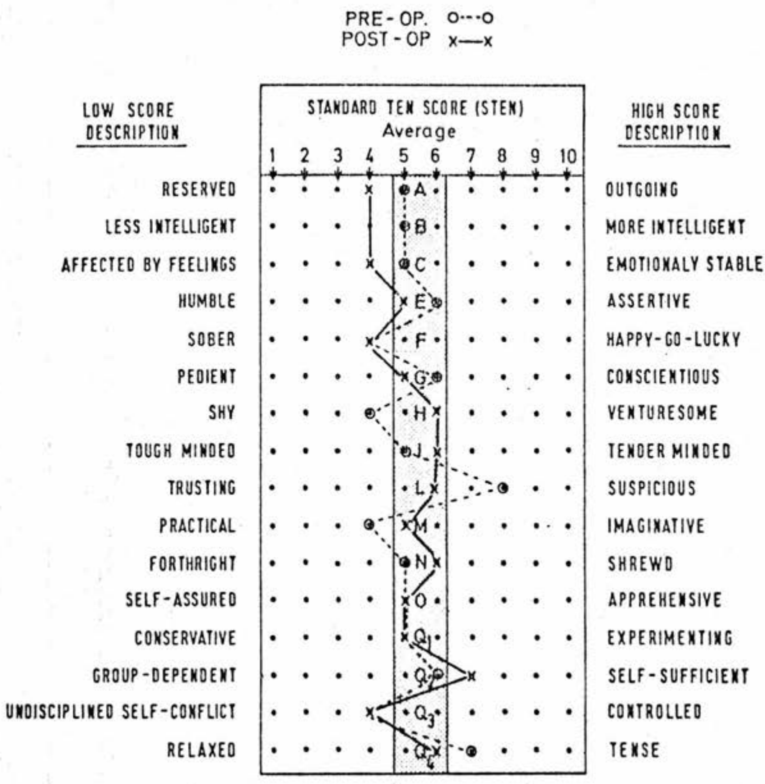

Figure 22.7 Sixteen personality factor test profile (five amygdalotomy cases).

revealed very few changes postoperatively. The majority of pre- and postoperative scores were within the average band. The most extreme preoperative score was on the factor of suspiciousness. Postoperative score was average. The only other change noticed was a decrease in shyness (Figure 22.7).

On the Hostility and Direction of Hostility Questionnaire (Caine, Foulds & Hope, 1967), the most notable feature was the very high total hostility (both pre- and postoperatively). Scores were more than two standard deviations above the normal mean and one standard deviation above the mean score for Personality Disorders. While there was no real change in total level postoperatively, there was a slight increase in intropunitiveness (Figure 22.8).

	Mean total score		Direction (+ scores are intropunitive)	
Amygdalotomies	Pre	Post	Pre	Post
5 cases, Pre & Post-op scores	26.8	25.4	+1	+5.8
4 cases, post-op scores only	24.7		+1	
Normative Data				
Normal controls	13		+0.5	
Personality disorder	18		+1.4	

Figure 22.8 Hostility and direction of hostility questionnaire.

We continue to use all the tests previously documented (Hitchcock *et al.*, 1972) in the assessment of cognitive function (Figure 22.9).

Amygdalotomy did not cause any significant changes in performance on tests of general intellectual function and short-term memory. We were also looking in more detail at memory function and learning, since an alteration in certain learning processes follows amygdalotomy (Andersen, 1972) and some of our patients, or their relatives, reported specific types of memory impairment. Previously we had concentrated on tests of short-term memory function on which deficits were not being detected.

We have therefore supplemented our battery by the inclusion of a further subtest from Williams Memory Scale (Williams, 1968—a test of non-verbal learning (the Rey-Davis pegboard test).

There may be an association between an impairment in face recognition following right temporal lobectomy and the type of deficit reported by some of our patients postoperatively, and we now also include a modification of a face recognition test, with the patient being required to select, from 24 photographs of faces, the 12 which he saw 1½ minutes previously.

COMPARISON OF PRE- AND POST-OPERATIVE TEST RESULTS

Raven's Progressive Matrices			
Mean change in score	No. +	No. -	No. same
+3.5	10	2	0

Mill Hill Vocabulary Scale			
Mean change in score	No. +	No. -	No. same
+1.7	6	4	2

Graham Kendall Memory for Designs			
Mean change in score	No. +	No. -	No. same
+0.7	7	4	1

Sentence Repetition		
No. +	No. -.	No. same
2	3	8

Figure 22.9 Cognitive function.

DISCUSSION

The potential value of these areas of study is debatable. On the basis of our experience of dealing with a selected group of patients submitted to a bilateral discrete psychosurgical procedure attempting to modify one aspect of behaviour, we would suggest that all psychosurgical studies should include a full psychiatric and psychological assessment, and that follow-up should be of at least 2 years. Whilst it is appreciated that the immediate effects of operation may be a valuable indication of suitable targets, only long-term follow-up with formal assessments can provide an adequate evaluation of the results of particular procedures.

The surgical procedure of amygdalotomy is relatively simple, and, although we have had no pathological verification, radiological technique is so good that target location was accurate. The amount of destruction necessary for a good result, however, is less well known. Some of our lesions have been small, and no attempt has been made to destroy the whole amygdala. The surgical target lay in the most medial part of the amygdala. Complications have been small and largely related to immediate postoperative difficulties of management. However, in one patient, as the result of an injury sustained during the removal of an indwelling electrode inserted via the transfrontal approach, a severe right hemiplegia was produced, which resulted in a considerable disability in one arm. The original lesions were small because of the fear of complications, but later on we tended to make larger lesions in an attempt to destroy a major part of the medial nucleus of the amygdala. To date we have had no complications from these large lesions.

Preliminary assessments indicate that very few cognitive changes are detectable following bilateral amygdalotomy. In several recent cases subtle memory deficits have been noted, both clinically and on tests, but they have been transitory and only detected in the first three postoperative months.

Throughout this study a major problem has been the care of violent patients in situations other than psychiatric hospitals. The introduction of such patients into a neurosurgical ward results in disruption and difficulties which may well influence nursing and medical staff assessment. It continues to be difficult to make relatives and attendants aware of the possible results of surgery, which in this particular series has been the apparently modest aim of reducing aggressive behaviour. Because these patients usually have associated personality disorders, and because, either as a result of their behaviour or associated with their behaviour, their social and domestic circumstances are invariably disturbed, it is important that the surgeon establish at a very early interview, the hopes of relatives and attendants of the outcome of successful surgery. It is our experience that unless the aim of surgery, in this case the elimination or reduction of aggression, is clearly stated, patient, relatives and attendants may be disappointed when their other multitudinous problems remain.

Our sample is small, and because all our assessment techniques were not available throughout the study, firm conclusions cannot be drawn. Our short-term results, however, in cases followed up for less than one year, are less impressive than many other published studies (Narabayashi, Nagao, Saito, Yoshida & Nagahata, 1963; Heimburger, Whitlock & Kalsbeck, 1966).

Long-term assessments are more relevant and the longer the follow-up the more reliable the assessment. However, during such long-term observation variables other than the surgical procedure itself result in behavioural changes, and it is important that such long-term evaluation consider also the effects of maturation, domestic changes, occupational status and other factors. It is also difficult to determine how far changes in social factors were caused by or resulted in changes of behavioural pattern.

A study of a matched control group of patients with aggressive behaviour not referred for surgery would be extremely valuable, and it is hoped to include this in the next part of our research.

Bearing in mind the above limitations, it may, nevertheless, be useful to indicate such trends as have emerged. Being male, having a mental age of more than 6-year level, living at home and with the aggressive behaviour confined mainly to the home situation, would appear to offer a greater chance of improvement postoperatively. The importance of adequate rehabilitation facilities, prolonged postoperative psychiatric support and good communications between all those involved in management, cannot be overstressed.

ACKNOWLEDGEMENTS

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EPILEPSY, PERSONALITY AND BEHAVIOUR

by

Valerie M. Cairns

Department of Surgical Neurology,

Western General Hospital, Edinburgh

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INTRODUCTION

In a paper published in Epilepsia in 1970 Mignone, Donnelly and Sadowsky summarised the current state of knowledge in the field of epilepsy, personality and behaviour as follows: "Most investigators agree that epileptics suffer a higher incidence of psychiatric disturbances than found in a non-epileptic population at large......The main controversy stems from many clinicians arguing for a special relationship between psychomotor (or temporal lobe) epilepsy and general psychiatric disturbances, and/or aggressive impulsivity, schizophrenia, sexual dysfunction and affective disorders." Several studies have established that there is a higher incidence of epilepsy (based on clinical or EEG evidence) in psychiatric hospitals (Court, 1965), in subnormality hospitals (Eyman et al., 1970) and in the prison population (Gunn and Fenton, 1969). Conversely, people with epilepsy tend to show a higher than normal incidence of personality and behavioural disturbances. This has been demonstrated in school-age children (Graham and Rutter, 1968) and over a wider age range (Pond and Bidwell, 1960). There are discrepant findings about specific personality and behavioural correlates of psychomotor epilepsy (Stevens, 1966). Studies vary in terminology ("temporal lobe epilepsy", "psychomotor epilepsy" and so on) and in their criteria for inclusion of cases. The population from which the sample was drawn also varies with critical discrepancies in terms of age and psychiatric status (Gunn, 1973). Some studies rely on the clinical descriptive method. Court and Mignone both used standardised personality questionnaires. The present paper seeks to describe the use of questionnaires and methods of assessment based upon observation and objective measurement of behaviour of/

of patients undergoing neurological and neurosurgical investigation of epilepsy.

There are four hypotheses currently under investigation. First: that there is a high incidence of personality and behaviour disorder in cases of epilepsy undergoing inpatient neurological investigation. This can be demonstrated using standardised assessment techniques. The second hypothesis is that personality and behaviour assessments do not distinguish psychomotor from non-psychomotor epileptics. The third: that the incidence of personality and behaviour disorder is greater in the cases selected for surgery. The last hypothesis is that behaviour and personality can show changes postoperatively and that this tends to be related to changes in fit frequency and severity. (This is dealt with only briefly in this paper).

CASE MATERIAL AND METHODS

Data are presented on 106 patients who have undergone neurological investigation of epilepsy over the past four years. The majority were inpatients in the Department of Surgical Neurology, being considered for surgical treatment. However, any patient with a provisional diagnosis of epilepsy was eligible for inclusion. Selection was only in terms of availability for psychological testing. The age range is 5-57. Table I provides an analysis of the cases. To minimise the risk of obscuring real differences between epileptic and non-epileptic and between psychomotor and non-psychomotor patients it was decided to use either clinical or electroencephalographic evidence. Thus the "epileptic" category included anyone in whom frank fits were not verified but in whom the EEG was indicative of epileptic abnormality. If any past or present EEG findings indicated a temporal lobe disturbance and if, in the absence of EEG evidence/

evidence there was an indication of psychomotor seizures using the International Classification (Gastaut, 1970), the patient was classed as psychomotor. There are 55 psychomotor cases and 42 non-psychomotor. Cases where the only manifestation was of outbursts of aggressive behaviour were excluded from the psychomotor category. There were nine such cases, all referred by psychiatrists for investigation of the possibility of epileptic phenomena. Of the 106 patients, 55 underwent surgery. Each neurosurgeon is interested in a particular aspect of the surgical treatment of epilepsy and the three main procedures are discussed in this paper. These are (a) temporal lobe excisions, (b) stereotactic lesions in the amygdala, and (c) stereotactic lesions in central brain structures (target sites include Field of Forel, internal capsule, thalamus and pallidum).

There are approximately 10 cases in each group on whom the current assessment procedures have been used pre- and post-operatively.

Table II shows that in this group of patients there is an extremely high incidence of mental disorder. Many patients are referred on grounds of behaviour disturbance. The aim of stereotactic amygdalotomy is modification of abnormal aggressive behaviour rather than alleviating the epilepsy per se. Some 20% of the cases in this group were referred for amygdalotomy. Thus, approximately two thirds of the cases of mental disorder in the total group occurred in cases other than those referred for amygdalotomy.

Clinical classification provides adequate information for a general description of the population. It is however quite inadequate for quantitative evaluation of the effects of neurosurgical intervention on personality and behaviour. The methods described in this paper were introduced/

introduced as part of the pre- and post-operative assessment of surgical cases and have been extended to include cases undergoing investigation only.

The diversity of cases in terms of age and psychiatric status have necessitated a wide range of assessment methods. To date results for any one technique are available for only small numbers.

The techniques used in the assessment of personality and behaviour fall into three categories:

(a) Standard personality questionnaires.

(b) Rating scales and checklists based on observation of the patient's behaviour.

(c) Experimental situations of a mildly stressful nature.

These are described in detail elsewhere (Hitchcock et al., 1972; Hitchcock et al., 1973; Hitchcock and Cairns, 1973).

Four of these techniques have been selected as representative and the results are discussed in terms of these. The first two are questionnaires, the third is a checklist and the last is one of the experimental measures.

RESULTS

In terms of the original hypothesis it is useful to consider four separate analyses of each technique:

(1) Comparison of the whole group with other populations (normal, psychiatric, non-epileptic, non-neurological).

(2) Comparison between the psychomotor group and the non-psychomotor group.

(3) Comparison of the operated and the non-operated cases.

(4) For each of the main operative groups comparison of pre- and post-operative results.

16 Personality Factor Questionnaire (Cattell)

This provides a multidimensional measure of 16 distinct primary personality factors. Certain combinations of these yield measures of Anxiety and Introversion-Extraversion (second order factors). Cattell et al. (1970) provide personality profiles for different groups of psychiatric patients and for different physical disabilities. These profiles are derived from the mean scores of all the patients on each factor. Court (1965) administered this questionnaire to a group of 20 patients with temporal lobe epilepsy (acute admissions to a psychiatric unit).

Many of the patients in this study were too young or too dull to cope with even the 'low literacy' version of this questionnaire. Results are available for 38 cases. Figures 1-5 provide comparisons of the personality profiles obtained by different groups and Table III provides further data on these.

First the results can be compared with the profiles provided by Cattell and Court. The profile obtained by the 38 Edinburgh cases is mildly deviant, more in keeping with the profiles of groups with physical disability (ranging from deafness to locomotor disability), and less deviant than the profiles of the groups with mental disorder (neurotic, psychotic, psychopathic and criminal groups). It is also a much less deviant profile than Court's group of temporal lobe epileptics.

Figure 1 compares the profile obtained by the 26 cases of psychomotor epilepsy and the 12 cases of non-psychomotor epilepsy who were able to complete the questionnaire. Although discrepancies can be noted on individual factors (of which a more detailed analysis might be of interest), the correlation between the two profiles is positive (significant at the

0.05/

0.05 level). The greatest discrepancies occur on Factor I (the non-psychomotor group being more dependent and more sensitive) and on Factor G (the non-psychomotor group being more conscientious). The profile of this group of psychomotor cases is much less deviant than Court's group.

Figure 2 compares the profiles of 20 non-operated cases with the pre-operative profiles of 17 cases who underwent surgical treatment. The correlation of +0.45 between these two is significant at the 0.02 level. The greatest discrepancy occurs on Factor Q3, indicating that the operated patients are less well integrated and less controlled than the non-operated cases.

Figures 3-5 give the pre- and post-operative profiles for the three main operative groups. The numbers in each are small (5-6). Temporal lobectomy might be considered a more major operation than stereotactic procedures, but produces less change in personality as measured in this questionnaire. Results indicate that the greatest change is produced by 'central' lesions, with a negative correlation of -0.25 between the pre- and post-operative profile, which just fails to reach statistical significance ($0.1 > p > 0.05$). The direction of change is in keeping with clinical observation with signs of disinhibition (increase on Factor H), decrease in level of suspicion (Factor L), slight increase in assertiveness (Factor E) and marked increase in Extraversion (second order Factor II). The follow-up for all operated groups ranges from 2 weeks to 2 years, with a mean of 8 months, with no difference between the three groups. Thus the changes noted cannot be explained as immediate post-operative sequelae. Age is also comparable in all three groups (with a mean of 30.3 years). Amygdalotomy (which from the rationale for surgical intervention, might have been expected to produce greatest changes) appeared/

appeared to result in more change than temporal lobectomy but less than central lesions (where the procedure is designed to alleviate epilepsy rather than modify personality).

Two factors show a similar change of direction in the amygdalotomy and central groups. These are an increase in Factor H and a decrease on Factor L. However, in the amygdalotomy group this brings scores on both these factors to a more normal level, whereas in the central group postoperative scores are more deviant. The amygdalotomy group also show a decrease to a normal level on Factor Q4 (tension).

In considering postoperative changes in relation to change in seizure pattern, the three procedures will again be mentioned separately. In the temporal lobectomy group four patients were fit free, one case showed reduction in frequency of seizures and in one case there was no change, at the time of postoperative assessment. In the amygdalotomy group only one case showed a marked reduction in the frequency and severity of seizures. In the central group, the case with the shortest follow-up had no postoperative seizures, and two cases showed marked reduction in fit frequency and severity.

The Hostility and Direction of Hostility Questionnaire

Critics of the 16 Personality Factor Questionnaire claim that it does not distinguish adequately between long-standing personality traits and shorter-lived mood changes, emotional states. The Hostility and Direction of Hostility Questionnaire (HDHQ) was designed to measure this area and covers various aspects of hostility, including attitudes to others in terms of being critical of others or being self-critical, having feelings of guilt, or tending to act out, or projected hostility (related to paranoia). A measure of hostility is of particular relevance in considering the question/

question of behaviour disorders associated with epilepsy in which acting out in the form of aggressive, impulsive behaviour and irritability are claimed as prominent features. Table IV gives the results obtained in 33 cases completing the questionnaire. A comparison of the epileptic group with the standardisation sample of psychiatric patients indicates that the epileptic patients obtained a much higher mean. It has been reported that age is a critical variable in this questionnaire and so groups of students, more comparable in age with the epileptic patients, completed the questionnaire and they obtained a significantly lower mean score. The mean score for normal groups with a wider age range is even lower.

There is not a significant difference between psychomotor and non-psychomotor groups. Two of the nine cases in whom no epileptic phenomena were observed completed the questionnaire, obtaining a higher mean score than any other group. There is no difference between operated and non-operated groups. The postoperative drop in scores noted in the temporal lobectomy and central groups is not significant. There is virtually no change in the amygdalotomy group. In view of the lack of marked changes on this questionnaire, changes in fit frequency and severity will not be considered.

The Adaptive Behaviour Scale

Not all patients can complete personality questionnaires, but the behaviour of all patients can be observed and can be quantified using checklists and rating scales. The Adaptive Behaviour Scale is a check-list designed for use with institutionalised retardates. Part II of the scale covers 14 areas of maladaptive behaviour. The scale is completed by adults familiar with the patient - nursing staff, occupational therapists/

therapists, teachers. The checklist may also be completed by parents. Its use has been extended to include some non-institutionalised non-mentally retarded cases since the areas which it covers, particularly aggressive, destructive behaviour, are so relevant. It provides detailed descriptions of behavioural items such as "smashes windows", "kicks", "does the opposite of what was requested." It is completed by ticking whether any of these behaviours occur and if so whether this is occasionally or frequently.

Four of the 14 areas have been selected for discussion. These are listed in Table V (A,B,C,M). Mean scores obtained by different groups are contained in the body of the Table. Since it is maladaptive behaviour which is scored, any score above zero is indicative of behavioural disturbance. In the original standardisation sample the proportion of cases who showed no disturbance in a particular area of behaviour ranged from 20% to 70%.

Results have been obtained for 43 of the patient sample. In addition, results were obtained for a group of 27 patients with epilepsy in a local subnormality hospital. This group show significantly less violent and destructive behaviour and fewer psychological disturbances than the neurological patient sample. However, when the groups are matched for age and sex, the difference in level of violent behaviour is no longer significant but the matched institutionalised group still show fewer psychological disturbances than the neurological sample.

The psychomotor group show a higher level of psychological disturbance (which in this scale includes items such as reaction to frustration, disturbance of mood), but this is not statistically significant. The 14 psychomotor cases and the 21 non-psychomotor cases are compared with the/

the group of 6 cases in whom no epileptic phenomena were demonstrated; the latter have a significantly higher level of violent and destructive behaviour and of psychological disturbances. None of the differences between the operated and non-operated group means is significant, although the mean of the 22 operated cases is slightly higher. Four cases undergoing investigation for further surgery show higher levels of anti-social behaviour and psychological disturbances. Neither of the two main operative groups in whom pre- and post-operative results are available show a significant change in group means in any of the four areas.

Results have so far been discussed in terms of group means. This is a convenient way of summarising data. However, in dealing with patients as diverse as this sample, it is more meaningful to consider individual results particularly in the evaluation of the effects of surgical intervention. Figure 6 gives pre- and post-operative results on 13 cases on two areas of the Adaptive Behaviour Scale. The majority of these are cases in the amygdalotomy group, since this scale was introduced primarily to evaluate the effectiveness of this procedure. However, also included are three cases who underwent other surgical procedures (HC, temporal lobectomy; DM, bilateral stereotactic central lesions; SDu, insertion of a shunt for hydrocephalus). Patients whose behaviour as assessed by this checklist was not disturbed pre-operatively all remained not disturbed postoperatively. These cases are not included in this Figure. Eight of the 9 male cases showed a drop in the level of violent and destructive behaviour, in 4 of these cases abolishing this type of behaviour completely, whereas in the 4 female cases only one showed an improvement. On the area of psychological disturbances, which covers items such as reaction to frustration, mood changes, one patient's behaviour deteriorated postoperatively/

postoperatively, one (GC) showed virtually no change. Ten cases showed a marked improvement with 3 cases showing no psychological disturbances postoperatively. Two of these are in the other, not in the amygdalotomy group. Cases DG, DM, FK and SDu all showed marked reduction in fit frequency.

Mirror Drawing

This is one of three experimental measures aimed at covering the areas of behaviour so frequently associated with "the epileptic personality" - low frustration tolerance, over-reaction to stress (Hill, 1957, 1959).

Table VI indicates the results on one of these measures which is a mirror-drawing task. The patient is required to trace a path round various designs using only the mirror image as a guide. A group of student nurses described this task variously as "frustrating", "made them angry", and so on. The variable is the amount of time spent on the task, the instructions being given to the patient that he spends as long as he likes and lets the tester know when he wishes to stop. The reason for using this as a measure rather than devising a situation in which the patient is frustrated in a more positive way is from the point of view of safety and management. Many of these patients are extremely disturbed and to exacerbate the situation by experimental testing is not considered ethically justified. In this situation the patient is instructed to stop when he wants. The results so far have indicated that within the epileptic group as a whole significantly less time was spent on this task than was spent by a group of student nurses. As yet the numbers are rather small but the mean time spent by the patients was 8 minutes as compared with the student nurses 10.1 minutes. The differences within the epilepsy groups between psychomotor/

motor and non-psychomotor are not significant. The mean time for 3 cases in whom no epileptic phenomena were demonstrated was 3.2 minutes. This result is in keeping with those of other measures, i.e. that this small group show more deviant patterns than the other groups.

DISCUSSION

Many people are sceptical about the validity of the current methods of assessment of personality and behaviour used by psychologists. To them, it will appear that the results presented here, distinguishing this population from other epileptic populations, psychiatric populations and the normal populations, add no information to the description of psychiatric status provided in Table II, from which it was obvious that 80% of the population showed some form of mental disorder. If only qualitative descriptive information is desired, their criticism is justified. Where exact quantitative comparisons are required, then methods such as those described in this paper are necessary. While questionnaires can provide a useful method of self-rating, two factors limit their value in this type of population. The first is that not all patients are capable of completing them and the second is that they may fail to provide adequate data on areas of major importance. Recording what the patient actually does is likely to be much more useful. This paper has described the use of one such method, the Adaptive Behaviour Scale. The results for this scale were considered in two ways, first in terms of group mean scores and secondly for some of the operated cases as individual patient patterns. The results of the other three assessment techniques described in this paper were analysed only in terms of group means. This is useful as a preliminary analysis, but where differences between one patient and another are as great as in this sample more meaningful data is provided

by/

by looking at individual patient behaviour.

Currently we are also using more detailed checklist methods, covering 10 minute samples of behaviour. Thus, the trend is away from global assessments, where there can still be room for subjective judgments, to more objective recording of behavioural events as they happen. This type of method should also make it easier to correlate behaviour and seizure patterns. Although this is of the greatest importance in selection for surgical intervention of cases of behaviour disorder associated with epilepsy, it is an area in our study which has eluded satisfactory analysis.

This paper does not cover analysis of the data in terms of age of onset, frequency of seizures or medication. Cognitive function has been the subject of another paper (Cairns and Naughton, 1973). The data presented in this paper refute the distinction between psychomotor and non-psychomotor cases. It can be argued that there is a difference which the methods used fail to identify, or that the variables of age of onset of seizures and medication (which are not considered here) are crucial ones. The system of classification into psychomotor and non-psychomotor epilepsy was difficult to implement in many cases for, as many other studies have pointed out, the distinction between psychomotor and non-psychomotor epilepsy is much less clearcut in patients than in textbooks. For these reasons the results from this part of the study should possibly be regarded more critically.

It is of interest that cases of behaviour disturbance and personality abnormality occurred not only in the group referred for amygdalotomy on grounds of behaviour disorder, but also in cases undergoing other surgical procedures and in cases in whom no surgical intervention was indicated, with/

with the most deviant group of all being a small number of patients in whom no epileptic phenomena could be demonstrated. It is also of interest to note that behaviour and personality showed changes not only after amygdalotomy but also after temporal lobe excision and after stereotactic lesions in central areas of the brain. The extent to which these changes are related to the surgical procedure per se and the extent to which they are related to changes in seizure pattern, is not resolved.

CONCLUSION

The data available on a sample of 106 patients undergoing neurological investigation of epilepsy suggest that personality questionnaires, observation of behaviour and measurement of performance in stressful situations confirm this group as deviant from other populations of patients with epilepsy, from psychiatric populations, and from a normal population. Each assessment method has been used with only limited numbers of the total sample. It is felt that observational techniques provide the most useful data in this type of population. Within the 106 cases, the assessment methods fail to differentiate between cases of psychomotor and cases of non-psychomotor epilepsy; nor do they differentiate between cases selected for surgery and non-operative cases. A very small number of cases in whom no epileptic phenomena were demonstrated are distinguished from the rest of the sample as being more hostile, more violent and destructive and less able to tolerate frustration.

Postoperative changes in personality and behaviour fail to reach statistical significance when each operative group is considered as a whole. However, in such a diverse population methods enabling analysis of individual cases are likely to be more valuable. This type of analysis of results of observational/

observational methods reveals quite marked postoperative improvements which tend to be associated with decrease in frequency and severity of seizures.

ACKNOWLEDGEMENTS

I am greatly indebted to the MacRobert Epilepsy Research Grant for financing this project; to nursing staff in the Department of Surgical Neurology, M.R.C. Brain Metabolism Unit, Gogarburn Hospital and other psychiatric hospitals for their co-operation in assessment of patients; to colleagues in the Department of Surgical Neurology and particularly to Dr. J.A.L. Naughton for his helpful advice and to Mr. E.R. Hitchcock for his enthusiastic support of attempts to develop a scheme of assessment of behaviour of patients undergoing amygdalotomy; to Mrs. Edna Cumpstey for invaluable assistance as research secretary.

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CAPTIONS FOR FIGURES/

CAPTIONS FOR FIGURES

Figures 1-5

16 PF comparison of group profiles.

Figure 6

Adaptive Behaviour Scale: Individual Results. Areas A & M. Pre- and post-operative levels in two areas of maladaptive behaviour, derived from raw scores. The vertical axis indicates percentile rank, the stippled area the percentage of an equivalent population obtaining zero scores. Length of follow-up is indicated along the horizontal axis, each case being plotted separately.

Fig. 1

16 P.F. TEST-PROFILE

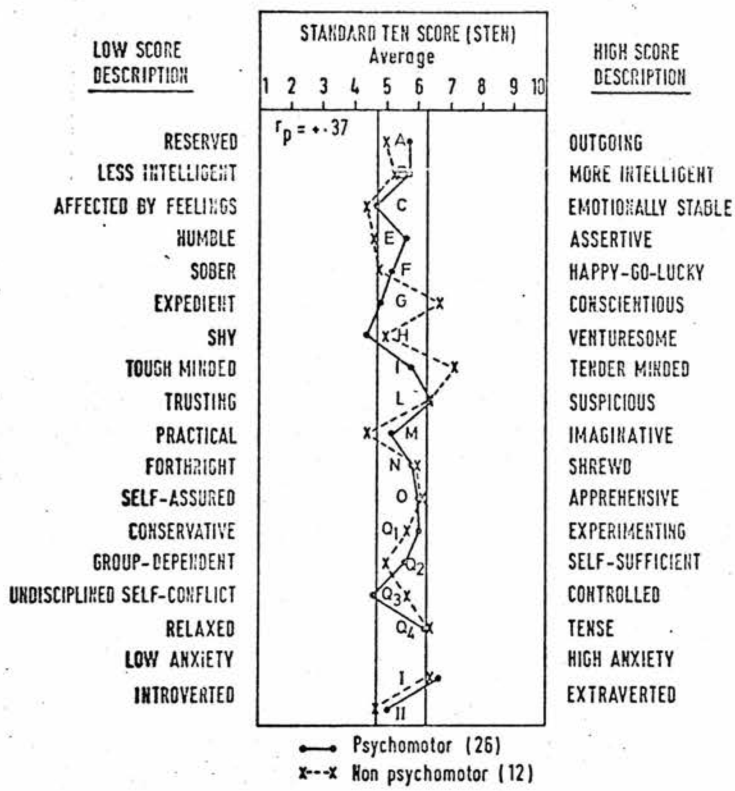

Fig. 2

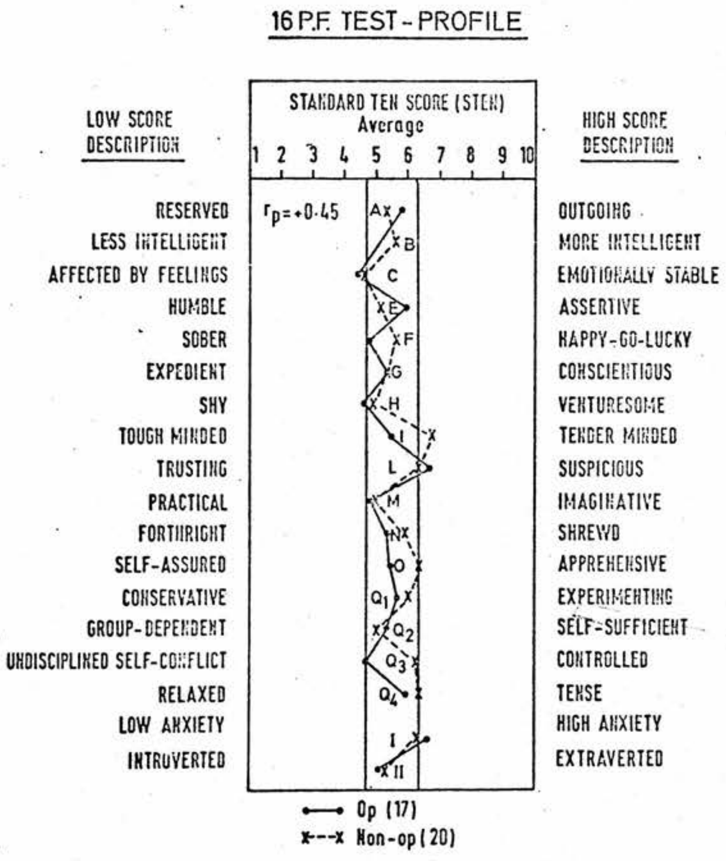
16 P.F. TEST - PROFILE
LOW SCORE DESCRIPTION
STANDARD TEN SCORE (STEN)
Average
1 2 3 4 5 6 7 8 9 10
HIGH SCORE DESCRIPTION
$r_p = +0.45$
RESERVED
LESS INTELLIGENT
AFFECTED BY FEELINGS
HUMBLE
SOBER
EXPEDIENT
SHY
TOUGH MINDED
TRUSTING
PRACTICAL
FORTHRIGHT
SELF-ASSURED
CONSERVATIVE
GROUP-DEPENDENT
UNDISCIPLINED SELF-CONFLICT
RELAXED
LOW ANXIETY
INTROVERTED
A
B
C
E
F
G
H
I
L
M
N
O
Q_1
Q_2
Q_3
Q_4
I
II
OUTGOING
MORE INTELLIGENT
EMOTIONALLY STABLE
ASSERTIVE
HAPPY-GO-LUCKY
CONSCIENTIOUS
VENTURESOME
TENDER MINDED
SUSPICIOUS
IMAGINATIVE
SHREWD
APPREHENSIVE
EXPERIMENTING
SELF-SUFFICIENT
CONTROLLED
TENSE
HIGH ANXIETY
EXTRAVERTED
•—• Op (17)
x--x Non-op (20)

Fig. 3

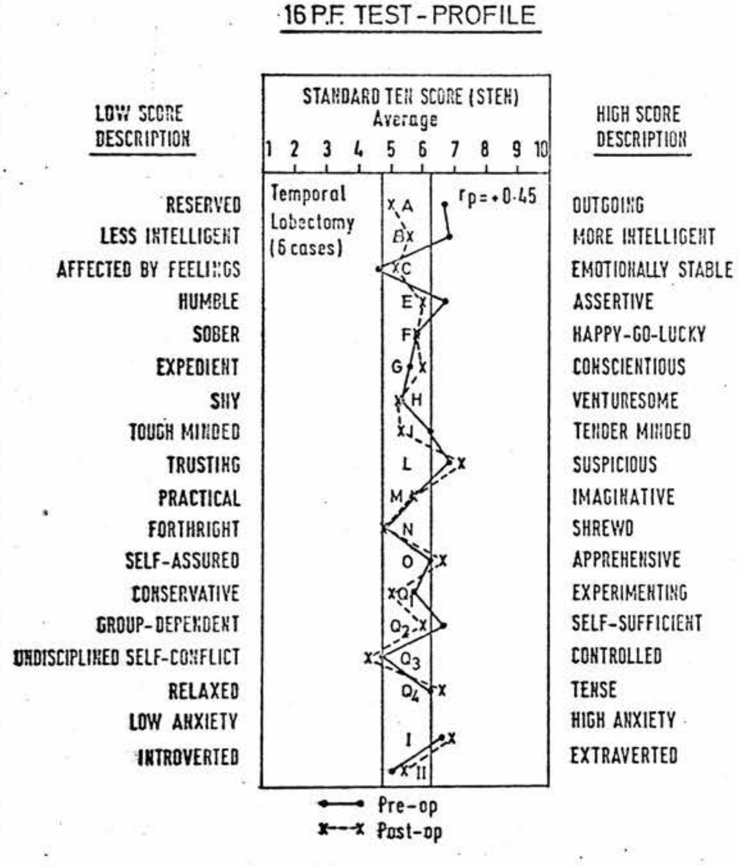
16 P.F. TEST - PROFILE
LOW SCORE DESCRIPTION
STANDARD TEN SCORE (STEN)
Average
1 2 3 4 5 6 7 8 9 10
HIGH SCORE DESCRIPTION
Temporal Lobectomy (6 cases)
rp = +0.45
RESERVED
LESS INTELLIGENT
AFFECTED BY FEELINGS
HUMBLE
SOBER
EXPEDIENT
SHY
TOUGH MINDED
TRUSTING
PRACTICAL
FORTHRIGHT
SELF-ASSURED
CONSERVATIVE
GROUP-DEPENDENT
UNDISCIPLINED SELF-CONFLICT
RELAXED
LOW ANXIETY
INTROVERTED
A
B
C
E
F
G
H
I
L
M
N
O
Q_1
Q_2
Q_3
Q_4
I
II
OUTGOING
MORE INTELLIGENT
EMOTIONALLY STABLE
ASSERTIVE
HAPPY-GO-LUCKY
CONSCIENTIOUS
VENTURESOME
TENDER MINDED
SUSPICIOUS
IMAGINATIVE
SHREWD
APPREHENSIVE
EXPERIMENTING
SELF-SUFFICIENT
CONTROLLED
TENSE
HIGH ANXIETY
EXTRAVERTED
Pre-op
Post-op

Fig. 4

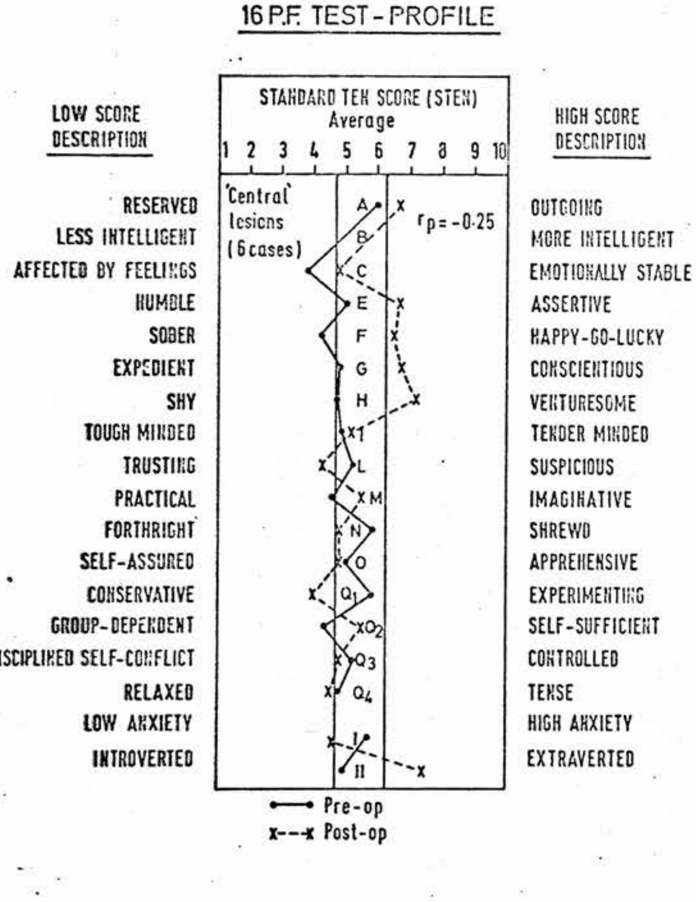
16 P.F. TEST-PROFILE
LOW SCORE DESCRIPTION
STANDARD TEN SCORE (STEN)
Average
1 2 3 4 5 6 7 8 9 10
HIGH SCORE DESCRIPTION
'Central' lesions (6 cases)
rp = -0.25
RESERVED
LESS INTELLIGENT
AFFECTED BY FEELINGS
HUMBLE
SOBER
EXPEDIENT
SHY
TOUGH MINDED
TRUSTING
PRACTICAL
FORTHRIGHT
SELF-ASSURED
CONSERVATIVE
GROUP-DEPENDENT
UNDISCIPLINED SELF-CONFLICT
RELAXED
LOW ANXIETY
INTROVERTED
A
B
C
E
F
G
H
I
L
M
N
O
Q1
Q2
Q3
Q4
I
II
OUTGOING
MORE INTELLIGENT
EMOTIONALLY STABLE
ASSERTIVE
HAPPY-GO-LUCKY
CONSCIENTIOUS
VENTURESOME
TENDER MINDED
SUSPICIOUS
IMAGINATIVE
SHREWD
APPREHENSIVE
EXPERIMENTING
SELF-SUFFICIENT
CONTROLLED
TENSE
HIGH ANXIETY
EXTRAVERTED
Pre-op
Post-op

Fig. 5

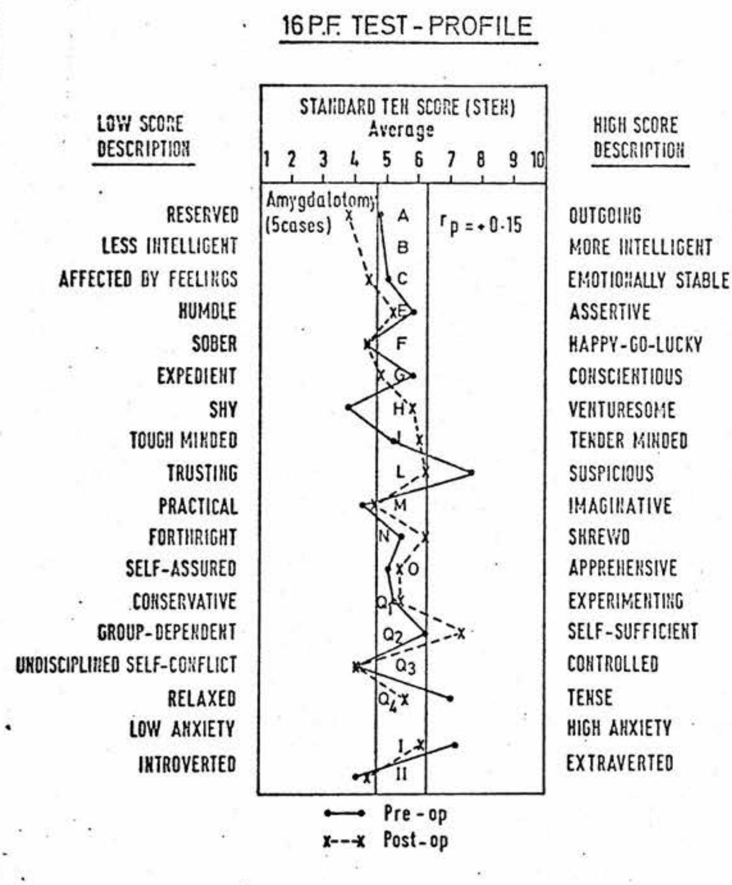
16 P.F. TEST - PROFILE
LOW SCORE DESCRIPTION
STANDARD TEN SCORE (STEN)
Average
1 2 3 4 5 6 7 8 9 10
HIGH SCORE DESCRIPTION
Amygdalotomy (5cases)
$r_p = +0.15$
RESERVED
A
OUTGOING
LESS INTELLIGENT
B
MORE INTELLIGENT
AFFECTED BY FEELINGS
C
EMOTIONALLY STABLE
HUMBLE
E
ASSERTIVE
SOBER
F
HAPPY-GO-LUCKY
EXPEDIENT
G
CONSCIENTIOUS
SHY
H
VENTURESOME
TOUGH MINDED
I
TENDER MINDED
TRUSTING
L
SUSPICIOUS
PRACTICAL
M
IMAGINATIVE
FORTHRIGHT
N
SHREWD
SELF-ASSURED
O
APPREHENSIVE
CONSERVATIVE
Q_1
EXPERIMENTING
GROUP-DEPENDENT
Q_2
SELF-SUFFICIENT
UNDISCIPLINED SELF-CONFLICT
Q_3
CONTROLLED
RELAXED
Q_4
TENSE
LOW ANXIETY
I
HIGH ANXIETY
INTROVERTED
II
EXTRAVERTED
Pre - op
Post - op

Fig. 6

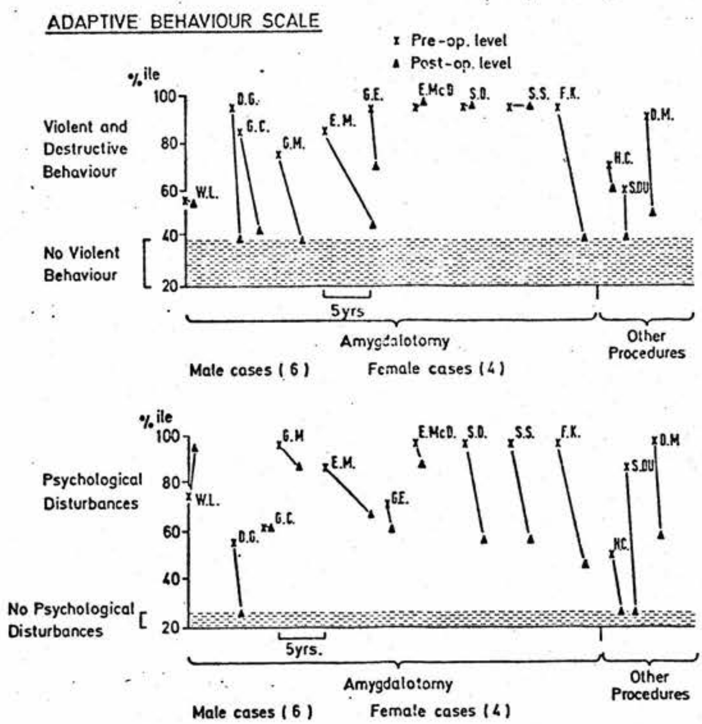
ADAPTIVE BEHAVIOUR SCALE
x Pre-op. level
▲ Post-op. level
%ile
100
80
60
40
20
Violent and Destructive Behaviour
No Violent Behaviour
W.L.
D.G.
G.C.
G.M.
E.M.
G.E.
E.McD
S.D.
S.S.
F.K.
H.C.
S.DU
D.M.
5yrs
Amygdalotomy
Other Procedures
Male cases (6)
Female cases (4)
%ile
100
80
60
40
20
Psychological Disturbances
No Psychological Disturbances
W.L.
D.G.
G.C.
G.M
E.M.
GE.
E.McD.
S.D.
S.S.
F.K.
H.C.
S.DU
D.M
5yrs.
Amygdalotomy
Other Procedures
Male cases (6)
Female cases (4)

TABLE I

ANALYSIS OF 106 CASES

	Epileptic		Non Epileptic	Total
	Psycho-motor	Non Psycho-motor		
No operation	17	23	6	46
Operation	37	15	3	55
Tumour	1	4	0	5
Total	55	42	9	106

TABLE II

CLINICAL DESCRIPTION OF PSYCHIATRIC STATUS

Description	Number
(i) Normal	23
(ii) Mentally retarded	
(a) without behaviour disturbance	7
(b) with behaviour disturbance	26
(iii) Personality disorder	25
(iv) Neurotic	11
(v) Psychotic	14
Total	106

TABLE III

16 PERSONALITY FACTOR QUESTIONNAIRE

	Correlation of group profiles		Normal Mean 5.5. Sten Scores — Second order factors			
			I Anxiety		II Extraversion	
	rp	Level of significance				
(1) Psychomotor (26) : Non-psychomotor (12)	+0.37	$p < .05$	6.6	6.4	5	4.7
(2) Operated (17) : Non-operated (20) (pre-op. profiles)	+0.45	$p < .02$	6.5	6.3	5	5.1
(3) Temporal lobectomy cases (6) Pre- and post-op.	+0.45	$p < .01$	6.6	6.9	5	5.4
(4) Amygdalotomy cases (5) Pre- and post-op.	+0.15	N.S.	7.1	6.1	4	4.4
(5) Central lesions (6) Pre- and post-op.	-0.25	N.S.	5.6	4.5	4.9	7.4

TABLE IV

HOSTILITY AND DIRECTION OF HOSTILITY QUESTIONNAIRE

	Group	No.	Score
(1)	Non Epileptic Psychiatric	169	18.4
	Epileptic	33	23 *
	Students	86	17.2
(2)	Psychomotor	18	22.9
	Non Psychomotor	14	23.3
	Non Epileptic	2	27
(3)	Operation	14	24.3
	No operation	19	22
(4)	Temporal lobectomy		
	Pre-operative	5	24.2
	Post-operative	5	20.4
(5)	Amygdalotomy		
	Pre-operative	5	26.8
	Post-operative	5	26
(6)	"Central" lesions		
	Pre-operative	4	21.2
	Post-operative	4	17

* $X^2 = 12.1$

$P < .001$

TABLE V

ADAPTIVE BEHAVIOUR SCALE (GROUP RESULTS)

Group	No.	A Violent and destructive behaviour	B Antisocial behaviour	C Rebellious behaviour	M Psychological disturbances
(1) Institutionalised subnormal epileptics	27	1.6	5.5	4.3	5.3
Institutionalised subnormal epileptics matched for age and sex with:	10	4.6 *	3.5	3.1	5.2 **
Neurological sample of patients with epilepsy	43	7.8	10.0	8.7	9.1 *
(2) Psychomotor	14	5.7	8.3	9	10.6
Non Psychomotor	21	5.8	6.6	6.6	5.4
Non Epileptic	6	14.6 ≠	16.7	11.8	14.0 ≠
(3) Operation	22	9	9.8	9.1	8.5
No operation	17	5.4	7.8	7.4	7.5
Post-op. ? further surgery	4	6	14.5	9.5	17.8
(4) Temporal lobectomy					
Pre-op.	4	8.8	3.7	3.5	6.3
(5) Amygdalotomy					
Pre-op.	10	13.6	16.6	15.3	12.9
Post-op.	10	10	10	7.7	7.9
(6) 'Central' lesions					
Pre-op.	6	3.3	4.5	3.8	3.5
Post-op.	6	0.9	1.3	0.6	0.8

≠ Difference significant at 0.05 level

** Difference significant at 0.02 level

* Difference significant at 0.01 level

A zero score is normal.

Any score above zero indicates disturbed behaviour

TABLE VI

MIRROR DRAWING

Group	No.	Time spent in minutes (maximum 15)
(1) Psychomotor	13	7.7
Non Psychomotor	16	9
Non Epileptic	3	3.2
Post-operative cases	8	8.4
(2) Student nurses	22	10.1 *
(3) Total patient group	43	8

* $X^2 = 4.09 \quad P < .05$

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Amygdalotomy

EDWARD HITCHCOCK
F.R.C.S.

VALERIE CAIRNS
M.A.

Department of Surgical Neurology, University of Edinburgh, Western General Hospital, Edinburgh

Summary

The results of a multi-disciplinary research project into the management and assessment of patients with epilepsy and behaviour disturbances are reported in eighteen patients who have undergone amygdalotomy over the past 5 years. The psychological and neurosurgical assessments are detailed and the effects of stimulation and coagulation of the amygdala nucleus are described in six patients.

It is concluded that certain cases benefit by amygdalotomy, but that changes are not limited to a decrease in abnormal aggressive behaviour but also lead to a decrease in other areas of maladaptive behaviour. The aim of the operation is to enable the patient to respond more appropriately in a range of situations which in turn would lead to an increase in general effectiveness.

Introduction

The significance of the deep structures of the temporal lobe and the limbic system in mediating emotional responses has long been recognized (Papez, 1937; Kluver & Bucy, 1939) and the existence of a relationship between certain forms of epileptic activity and disorders of emotional reactions has also been well documented (Weil, 1959; Flor-Henry, 1969; Falconer & Taylor, 1970; Horowitz *et al.*, 1970).

Gloor (1960) suggested that certain limbic structures have a very low threshold for electrical activity, and areas of the limbic system have become particularly important in exploring the relation between neuro-physiology and behaviour. Over the past 30 years there have been two main streams in the development of neuro-surgical approaches in this field; frontal lobe lesions to modify affective states, and temporal lobe procedures for behaviour disorders associated with temporal lobe epilepsy.

The amygdala, a limbic structure within the temporal lobe, has been studied more in animals than in man (Eleftheriou, 1972). It is concerned with attention, orientation and learning as well as eating, drinking, sexual and aggressive behaviour. Many of the techniques used in animal experiments cannot be used in the exploration of the amygdala in humans. Nevertheless, the possibility that abnormal patterns of aggressive behaviour might be associated in some way with the abnormal functioning of the amygdala led to the investigation of the effects of destruction within this area (Narabayashi *et al.*, 1963; Heimburger, Whitlock & Kalsbeck, 1966). In human studies global terms such as aggression and behaviour disturbance continue to be used.

Feindel (1960), Jasper (1960), Gregory (1961) and Weiskrantz (1968) have indicated that stimulation or ablation studies do not permit valid conclusions about the function of specific brain structures. In this present study, therefore, we make no inferences from changes in behaviour pattern following partial or complete destruction of the amygdala. Vowles (1970) indicates that 23 subnuclei have been identified within the human amygdala, but we have no specified information about the facilitatory or inhibitory role of these.

The amygdalotomy project

The amygdalotomy project has developed from an isolated surgical project into a multi-disciplinary team approach, in which the neuro-surgeon, the psychiatrist and the psychologist are involved in the management and assessment of patients with epilepsy and behaviour disturbances treated by temporal lobe surgery (Hitchcock *et al.*, 1972). At the outset of the project it was felt that neither psychological nor psychiatric assessments could provide adequate selection criteria and so it was decided that within the group of cases with behaviour disorders referred to the neuro-surgeon, selection would be made by the neuro-surgeon. Thereafter, cases selected would be assessed by a psychiatrist and a psychologist and a period of detailed in-patient investigation in a psychiatric unit would be arranged for the immediate pre- and post-operative period. The patient would then be re-assessed at varying post-operative intervals, more frequently within the first year and thereafter annually. An indispensable part of the project is close liaison with the psychiatrists in the MRC Brain Metabolism Unit of the Royal Edinburgh Hospital. Dr George Ashcroft and his colleagues provide both out-patient and in-patient assessments and also active support during the period of post-operative rehabilitation.

Patient characteristics

The age range of the eighteen patients who have undergone amygdalotomy over the past 5 years is 8–46 years. There were five females to thirteen males. Reasons for referral all centred round behavioural disturbances in which abnormal aggressive behaviour of some description featured to a greater or lesser extent. In five cases there was a pattern of severely subnormal mental functioning (mental age 1–7 years). Behaviour in this group is described as hyperactive, destructive and rebellious. Normal patterns of emotional control have failed to develop. Their behaviour is appropriate to their mental level but physical strength greatly out-strips mental capacity and hence their behaviour, which would be acceptable in a normal toddler, has unacceptable consequences. In five adolescents, the problem behaviour centred round violent outbursts usually directed against authority, in three cases mainly against parents. The most effective group, in terms of functioning within the normal intellectual range, living at home with only intermittent hospitalization and either occasionally employed or holding down a regular job, were four male cases whose problems of aggressive behaviour were associated with alcohol. The remaining four cases were all adult and presented with a history of personality disturbance and, in three, periods of psychiatric hospitalization. Sixteen of these eighteen cases suffered from or had a history of epilepsy.

Methods

Psychological testing is extremely difficult since the absence of co-operation is frequently a contributory factor in referral. Personality questionnaires are appropriate for only a limited number of our population, many being too dull intellectually. In all patients, however, behaviour can be observed and can be quantified through the use of check lists and rating scales. A recent development has been obtaining measures of patient behaviour in certain standard situations designed to be mildly frustrating or stressful. The complete psychological assessment is described in the Appendix.

Because of the close association of the amygdala with the hypothalamus and its influence on the endocrine system, it is hardly surprising that hormonal disturbances were manifest post-operatively in some patients. The project has broadened, therefore, to include a biochemical study performing hormonal assay examining the continuous urinary testosterone excretion pre- and post-operatively. Biochemical analyses in the pre- and post-operative period have been confined to CSF concentrations of amines. The amygdala is rich in 5 HT and if this contributes to the 5 HIAA metabolite levels of CSF one could expect to see changes in the CSF concentration of 5 HIAA post-operatively. This aspect of the work is carried out by staff in the MRC Brain Metabolism Unit.

The neuro-surgical investigations comprised LAEG, EEG, angiography, and cerebral isotope scan. Although EEG revealed abnormalities with focal evidence of temporal lobe disturbance in some patients, the most helpful examination appeared to be LAEG. The surgical procedure involved the bilateral stereotactic placement of electrodes within the amygdala and its destruction by a radio-frequency current. The early approaches to the amygdala were transfrontal, the electrode traversing other parts of the brain than the temporal lobe. Although the damage must be small, to eliminate any possibility of damage of such structures influencing the assessment the direct transtemporal approach has been used for all but the first two or three cases (Fig. 1). A further advantage of this approach has been a shorter brain track and an opportunity to record and stimulate from temporal lobe structures en route to the amygdala. Wherever possible, procedures were performed without premedication under local anaesthesia. Nine patients have been operated on under local anaesthesia. The remaining nine patients had bilateral amygdalotomy performed under general anaesthesia because it was considered that in view of their behaviour disturbance, undergoing the procedure under local anaesthesia would be too hazardous. For six of the patients who underwent the procedure under local anaesthesia the effects of stimulation and coagulation were recorded in detail with the use of a tape recorder. Some of the case characteristics of these six patients are shown in Table 1. The age range of this group was 17–44 years. Five of the six patients were male. Our stimulus parameters are comparable with those of other studies (Chapman, 1958), 5–100 Hz, pulse width 1 msec, voltage ranging from 1 to 10 using a Radionics thermoprobe electrode with exposed tip dimensions 3 mm $\times$ 1·8 mm. Stimulation was carried out as the probe advanced towards the target at various points short of target, on target and occasionally beyond target. Where it was feasible, stimulation was repeated to ensure that the response obtained was not an artefact of the situation, but where extremely aggressive responses were being obtained and the patient was becoming disturbed it was not considered desirable to repeat these more than was absolutely necessary for localization purposes to identify the target area.

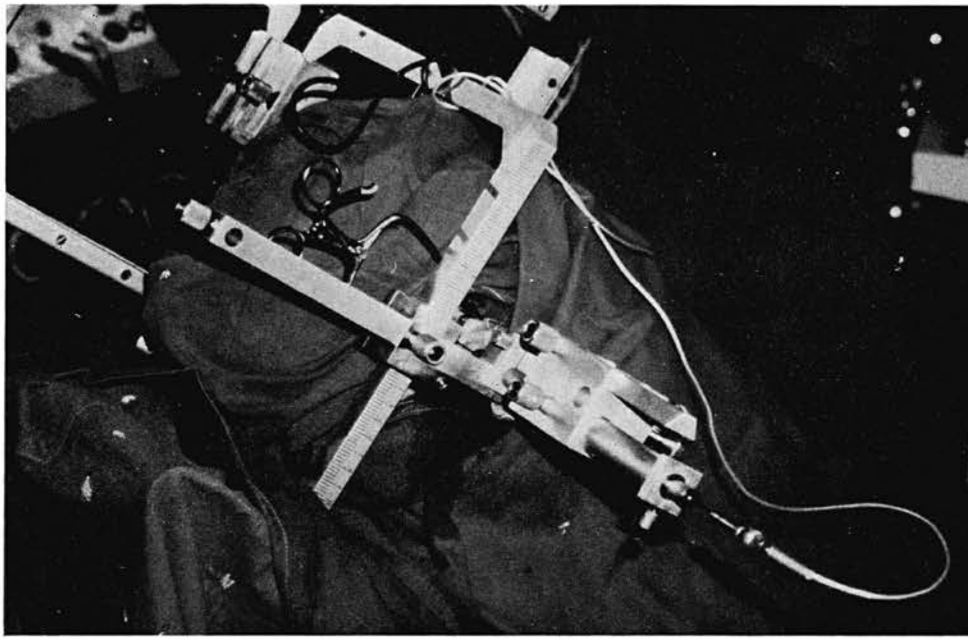


FIG. 1. Probe introduced through direct temporal route.

TABLE 1. Details of six cases undergoing amygdalotomy under local anaesthesia

Patient	Sex	Age at operation (years)	Operation	Date	Seizure type	EEG focus	Main presenting complaints	Intelligence
W.L.	M	34	Bilateral	14.7.71	? Psychomotor	No EEG abnormality	Aggressive behaviour and drinking problem	Average
H.F.	M	42	Unilateral left (previous right-sided lesion)	4.5.70 24.6.67	Focal	Bilateral temporal abnormality (pre first operation)	Aggressive behaviour and drinking problem	Average
W.G.	M	29	Bilateral	23.10.70	Major + temporal lobe fits	No significant abnormality	Aggressive behaviour and drinking problem	Average
D.G.	M	17	Bilateral	26.8.71	Jacksonian + major	Left occipital focal disturbance	Aggressive behaviour (to parents only)	Severely subnormal
G.M.	M	44	Bilateral	27.1.70	Temporal lobe	Sphenoidal EEG Right inferior temporal disturbance	Aggressive behaviour (self-reported, never observed) and drinking problem	Average
E.M.	F	18	Bilateral	18.5.72	None	None	Behaviour disturbance (with violent and self-mutilative behaviour	Severely subnormal

Results

Before dealing with the long-term results for the whole group we will describe some of the results obtained for the six cases for whom detailed records of responses during stimulation and coagulation under local anaesthesia are available. These are recorded in Table 2.

The most significant (and the most dramatic) effect of stimulation has been the eliciting of a range of aggressive responses from coherent, appropriately directed verbal responses (speaking to surgeon, 'I feel I could get up and bite you') to uncontrolled swearing and physically destructive behaviour. While all these patients had a history of abnormally aggressive behaviour, during in-patient investigations, psychological testing, etc., such behaviour as occurred during stimulation was not observed at all. In four patients a similar pattern of restless behaviour was obtained which included tearing at drapes and clothes, moving hands up towards the stereotactic frame and trying very forcibly to remove this frame. This characteristic pattern occurred during coagulation as well as during stimulation in two of these four patients. It appeared purposive but had an automatic quality. It was not susceptible to modification as a result of external stimulation, i.e. verbal commands to move the hands from the frame or not to tear off the gown, and force was required in two cases to prevent the stereotactic frame being removed by the patient who before and after

TABLE 2. Tabulated results of behaviour during stimulation and coagulation in six patients

Description of behaviour	No. of patients in whom this response was obtained	
(1) Aggressive behaviour		
(a) Swearing	2	
(b) Shouting, sounding angry	3	
(c) Threat of violence	1	
(d) Restless, destructive behaviour	4	
(2) Emotional, upset, tearfulness	1	These expressions of emotions were all associated with periods of confusion
(3) Other expressed emotions		
(a) Anxiety	1	
(b) Guilt	2	
(c) Embarrassment	1	
(d) Jealousy	1	
(4) Verbalized desire for 'flight', 'escape'	3	
(5) Expressed fatigue	2	
Signs of fatigue	4	
(6) Confusion	3	
(7) Disorientation		
(a) Place	1	
(b) Time	1	
(8) Unresponsiveness	5	
(9) Incoherent speech	4	
(10) Automatic speech	2	
(11) Automatic behaviour	4	
(12) Autonomic/visceral		
(a) Flushing	4	
(b) Thirst	2	
(c) Butterflies in stomach	1 (normal seizure pattern)	
(13) Motor		
(a) Upper limb movement	3	
(b) Jaw movement	2	
(c) Slurring of speech	3	
(14) Sensory		
(a) Visual		
(i) Diplopia	2	
(ii) c/o everything going black	1	
(b) Smell/taste	1	
(c) Feeling of electric shock, tingling	1	
(15) Seizures		
(a) Typical	3	
(b) Atypical	0	

these episodes appeared fully aware of the situation and refrained from touching the frame or from interfering with the operative procedure in any way or from interfering with the drapes, etc.

Two patients expressed other emotions during what appeared as periods of confusion. Three patients expressed a desire to get away. The significance of this, which might be termed 'flight' behaviour, in relation to known patterns following amygdaloid stimulation in animals in whom distinct patterns of flight, defence and attack responses have been observed (Kaada, 1972) is of some interest. No pleasurable emotional feelings and no responses connected with sexual behaviour were identified in any of our patients during stimulation or coagulation.

A comparison of the effects obtained during stimulation and coagulation of the amygdala with the features of psychomotor seizures (Chatrian & Chapman, 1960) shows them to be very similar. Where seizures occurred during the stimulation procedure these were of a similar nature to the patients' current seizure pattern (D.G., W.G., G.M.). Two of the patients reported these as identical and in the third patient they were observed to be identical. The question of whether the unresponsiveness noted in five of our patients was in fact no more than the occurrence of seizures was raised, but there were several instances of unresponsiveness in the two patients in whom there was no history of clinical seizures. During some of these periods of unresponsiveness the patient would at some times respond to non-verbal commands. At other times there was no response and not even an orienting to the source of the stimulus. These aspects ruled out the possibility that we were seeing no more than speech arrest frequently reported during stimulation of the peri-amygdaloid area. It is of some interest that the unresponsiveness occurred in two patients at exactly the same location at which verbal aggression and restlessness were previously or subsequently elicited. No clearcut pattern has as yet emerged between the onset of the stimulus and the occurrence of the response, or of persistence of response after cessation of stimulus. Some responses occurred within 3 sec of the onset of the stimulus and some responses persisted 1 min after the cessation of the stimulus.

In one of the two cases in which vehement swearing occurred, this was of sudden onset, 30–45 sec after stimulation commenced, on three separate occasions. The disturbance lasted for 15–30 sec and the patient became placid 5–30 sec after cessation of stimulation. On one occasion the patient was asked, 30 sec after cessation of the stimulus, if he had felt angry. He agreed that he had been angry, but that he no longer was, and he sounded very surprised (Table 3).

Although in the post-operative period some patients were so disturbed that they removed their dressings and fingered their wounds, post-operative infections were minimal and no serious infection arose.

TABLE 3. Record of stimulation responses: Stimulation of amygdala (patient W.L.; date, 13 July 1971; side, right)

Time	On/off	Frequency (Hz)	Voltage	Comments made and questions put to patient	Patient's responses: Verbal	Patient's responses: Observations
	At target					
0	On	50	3	Tell us if you feel anything.		7 sec delay—incoherent response.
0·12				What's happening?		6 sec delay.
					Yes.	
0·22				Mr L.	Yes.	
				Are you awake?	Yes.	
				How are you feeling?	OK.	
				Any funny feeling?	Yes, just	3 sec pause.
0·30				Just what?		3 sec pause. Long sigh.
					Just I'm getting sick of all this.	
0·35	Off			How are you now?	Just the same.	Still sounds angry.
0.40	On	5	4·5		My leg.	2 sec delay and then face flushing.
0.43					I can hardly speak*****	Patient swearing.
0.55				What's the matter?		10 sec delay.
					Everything going black.	
				What do you feel now?		3 sec delay.
1.10			5		I just want to get***** out of here.	Patient swearing, shouting very angrily.
1.20				That's OK.		
	Off			All right?	Yes.	
1.50				Did you feel angry?	Aye, I did.	Patient sounds surprised.
				Do you feel that now?	No, I don't feel that now.	

The surgical procedure is relatively simple and although we have had no pathological verification, radiological verification indicates that target siting was accurate. The amount of destruction necessary, however, is less well known. Some of the lesions made have been small and no attempt has been made to destroy the whole amygdala, the surgical target being the most medial nucleus of the amygdala. Complications have been small and largely related to immediate post-operative difficulties of management. In one patient, however, as the result of an injury sustained during the removal of an indwelling electrode inserted via the transfrontal approach, a severe right hemiplegia was produced which has resulted in a considerable disability in one arm. The original lesions were small because of the fear of complication but increasingly we have tended to make larger lesions in an attempt to destroy a major part of the medial nucleus of the amygdala. To date we have had no complications from these large lesions.

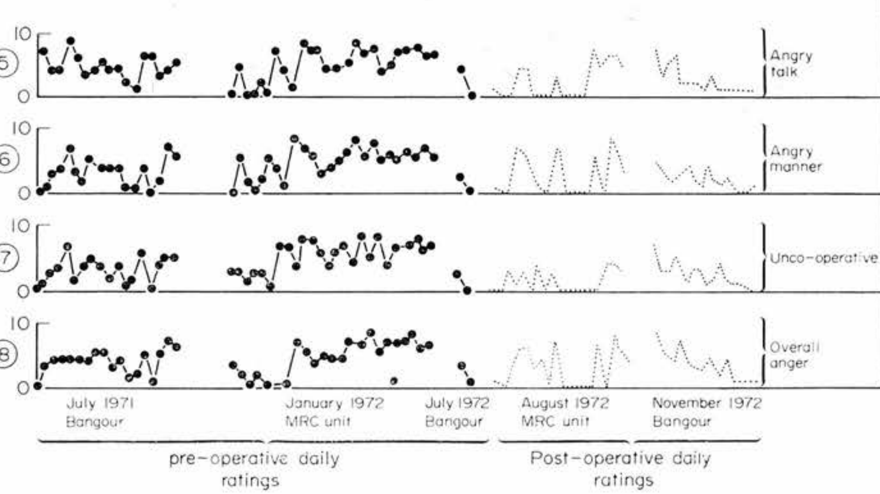
Frequency and severity of fits have been notably reduced in three cases (D.G., J.S., W.G.), with consequent reduction in anticonvulsants. Apart from in the immediate post-operative period, in no case has there been an increase in frequency or severity.

Tests of intellectual function showed no post-operative impairment. A subtle deficit in the recognition of faces has been reported in one or two recent cases. Perceptual and memory aspects of this are now being investigated.

The major psychological assessment, however, is of personality and behaviour. Five cases have completed Cattell's 16 PF Questionnaire pre- and post-operatively. The group personality profile indicates minor changes on a number of factors. Of particular interest is the post-operative decrease to a normal level on the factor related to suspiciousness. Total level of hostility (as measured by the Hostility and Direction of Hostility Questionnaire) remains high. These test results have been reported in detail elsewhere (Hitchcock *et al.*, 1973).

Observational methods have provided results on a larger number of patients. The Hargreaves Nursing Rating Scale provides a detailed record of patient behaviour, as shown in Fig. 2. It can be seen that although the mean level on item 7, for example, has dropped significantly, there are still marked day-to-day fluctuations.

In addition to the use of this rating scale, we have also made use of a checklist. The Adaptive Behaviour Scales, although devised for use with institutionalized retardates, are proving very useful for the majority of our cases. Figure 3 gives results for twelve patients on four of the areas covered by the scales. In four males the scores indicated a drop in violent and destructive behaviour, but in only one female. Three females remain more violent and destructive than 90% of an equivalent population. In all four females there was a high level of self-abusive behaviour which was reduced post-operatively in only one case, the same patient in whom there was a decrease in violent



	Mean pre-op. rating	Mean post-op. rating	Level of significance of difference (*t* test)
Angry talk	4·26	2·1	$P<0{\cdot}01$
Angry manner	4·19	1·97	$P<0{\cdot}01$
Unco-operative	4·71	1·86	$P<0{\cdot}01$
Overall anger	4·46	3·07	$P<0{\cdot}02$

FIG. 2. Hargreaves Nursing Rating Scale. Results for one patient (G.C.) on four of the total of twenty-four items, rated daily on a 10 point scale (from 0 = no disturbance, to 9 = extreme disturbance).

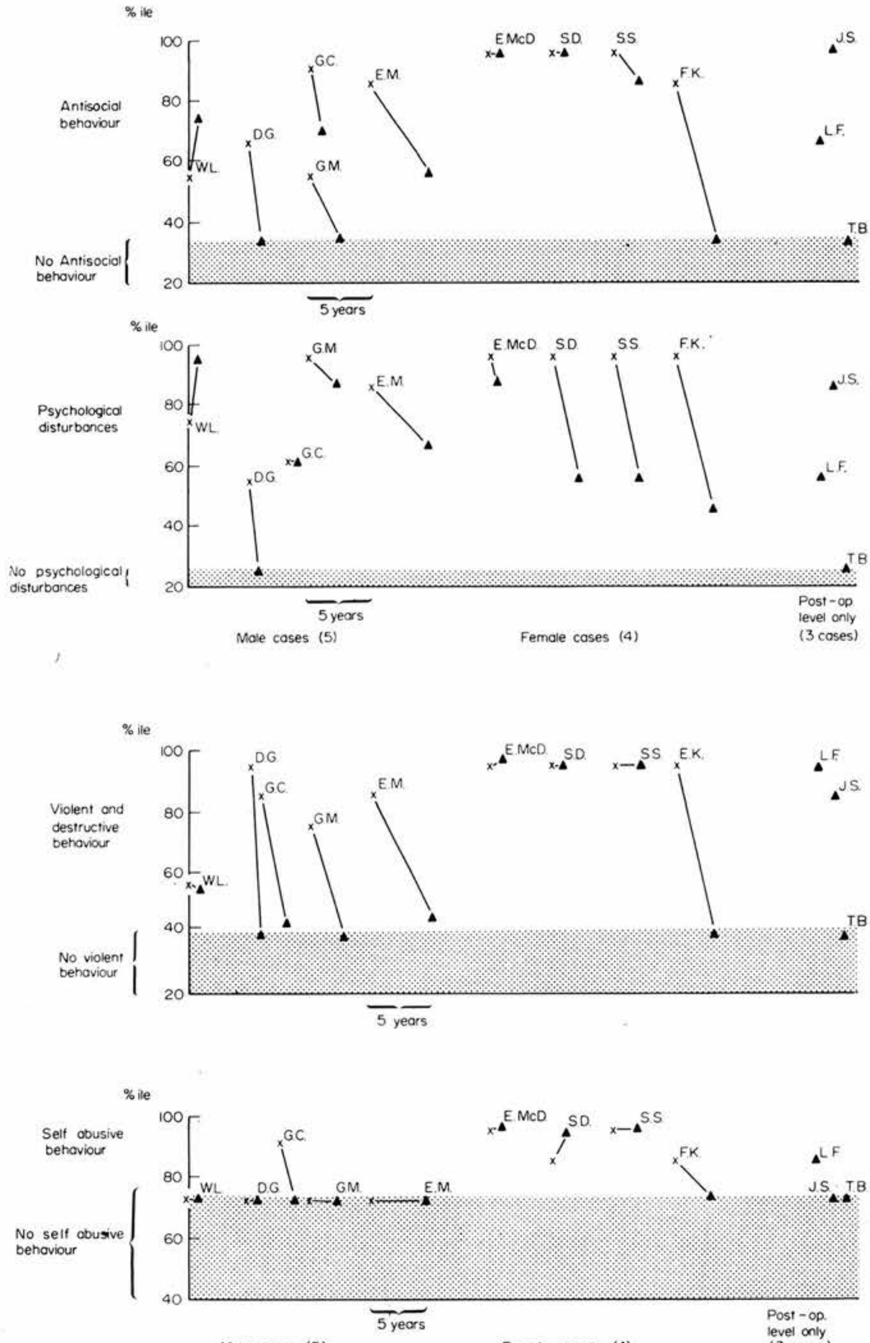


FIG. 3. Adaptive Behaviour Scales. Pre- and post-operative levels in four areas of maladaptive behaviour, derived from raw scores. The vertical axis indicates percentile rank, the stippled area the percentage of an equivalent population obtaining zero scores. Length of follow-up is indicated along the horizontal axis, each case being plotted separately. ×, pre-operative level; ▲, post-operative level.

and destructive behaviour. A range of behaviour, such as reaction to frustration, mood changes and hypochondriacal tendencies, are covered in the area labelled psychological disturbances. All cases show some degree of such disturbance pre-operatively and ten cases post-operatively. Six cases show a decrease (improvement) post-operatively, one an increase in level and two no real change. Three of the four cases (D.G., E.M., G.M. and F.K.) showing greatest overall improvement could be described as having adolescent problems pre-operatively and in the fourth there was a change in domestic circumstances. It would appear from these results that the cases where there is a decrease in violent, destructive behaviour and antisocial behaviour also show an all-round improvement in general effectiveness.

Of the fifteen cases on whom data is currently available, the five cases hospitalized pre-operatively remain in hospital. One patient who was at home pre-operatively is now in hospital, but hospitalization was imminent pre-operatively. As far as occupational activity is concerned, four of the nine patients previously incapable of any form of occupational activity are now either employed or attending occupational therapy units. A further four patients continue to be in either regular or occasional open employment post-operatively. From these figures we cannot claim, as other authors have done, that post-operatively a majority of patients become capable of effective functioning in a social context.

Discussion

It might be argued that this series of cases has no control group matched in terms of behaviour patterns and other variables. In view of the variation of individual patterns of maladaptive behaviour within our group, it is felt that this would not provide such valid information as our current design, in which each patient is used as his own control and the results are evaluated in terms of checklists for which age norms are available.

Long term assessments are more relevant than evaluation of the effects immediately post-operatively. However, during such long term observation variables other than the surgical procedure itself result in behavioural changes and it is important that such long term evaluation also considers the effects of maturation, domestic changes, occupational status and other factors. It is also difficult to determine how far changes in social factors are a cause of, or a result of, changes in behavioural patterns.

The study of behavioural responses occurring during stimulation of localized areas of the brain has been criticized in that such responses are artefacts which do not yield valid results (Mark, Sweet & Ervin, 1972) and even more so when these studies are carried out in the operating theatre (Sem-Jacobsen, 1970). In monkeys aggressive responses were elicited only in the appropriate social situation (Rosvold, Mirsky & Pribram, 1954). An operating theatre might be regarded as an inappropriate situation for the expression of emotional reactions.

The only aim of stimulation at surgery was in physiological localization prior to coagulation. In all of these patients the main, or one of the main, presenting complaints was a pattern of abnormal aggressive behaviour and hence we were particularly interested in the aggressive responses which were elicited. In our one-stage bilateral operations it may not even be possible to specify exactly that responses obtained during stimulation of the second side definitely are such, or no more than the delayed effect of stimulation and coagulation of the contralateral amygdala. Further objection to describing the functions of the amygdala in terms of results obtained during stimulation and coagulation at surgery is that we were not able to allow sufficient intervals between one stimulation and another or between stimulation and coagulation to extrapolate adequately the after-effects of one stimulation from the direct effects of the next. Again studies using chronic implanted electrodes, those of Sweet, Ervin & Mark (1969), King (1960) and Sem-Jacobsen (1970), with intervals of 5 to 10 min between stimulations, do enable more exact analysis to be made. However, with our patients it was not considered a necessary part of the pre-operative investigations to have implanted electrodes and it was not considered justifiable to use these merely for research purposes.

Many studies mention that negative emotions can be elicited by electrical stimulation (Heath & Mickle, 1960; Gloor, 1960) but few describe in detail the behaviour elicited. One exception to this is the work of Sweet *et al.* (1969) who do provide detailed description of telemetric stimulation in several patients. Comparison of our results with these published studies indicates that we were eliciting certain responses at surgery which had not been recorded previously.

Horowitz *et al.* (1970) described a turbulent period of post-operative re-adjustment and it is during this period, sometimes prolonged, that we have been very dependent on the support provided for the patient and the family by our psychiatric colleagues. Aspirations are frequently unrealistic and while pre-operatively the aims of surgery and the limitations have been carefully explained, patients and their relatives often expect the patient to be able to return to normal independent functioning, living at home, in the immediate post-operative period.

The neuro-surgeon's criterion for accepting a patient for surgery is based on a judgment; the judgment that the pattern of aggressive behaviour is detrimental to the patient's well-being, not that it is detrimental to society. The aim of surgical intervention has been to render the individual more effective rather than more manageable.

As with any therapeutic technique, there is the risk of misuse, but it is felt that non-surgical techniques (such as conditioning and drug therapy) may come under less careful scrutiny than psychosurgical procedures and hence may very well be more liable to misuse.

Conclusion

In view of the indications of abnormal epileptic activity in the majority of our cases it is not possible to generalize from our results to a non-epileptic population, but within our group in certain cases in certain situations behaviour after amygdalotomy is less disturbed. Results to date indicate that where this is so changes are not limited to a decrease in abnormal aggressive behaviour but there is also a decrease in many other areas of maladaptive behaviour. Human behaviour is extremely complex and to date it has not been possible to establish whether the decreases in aggression and other maladaptive behaviour occur simultaneously or whether, as initially hypothesized, the effect of a discrete lesion in the amygdala is to increase level of tolerance for frustration and increase inhibition of aggressive responses, thus enabling the patient to respond more appropriately in a range of situations which in turn would lead to an increase in general effectiveness.

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Appendix

Summary of psychological assessment

(A) *Tests of cognitive function*
- (i) General intellectual level
- (ii) Memory
- (iii) Miscellaneous

(*B*) *Personality and behavioural assessment*
- (i) Questionnaires
- (ii) Self-rating
- (iii) Rating Scales and Checklists
- (iv) Objective Measures

Patients are tested* pre-operatively, and at 1 month, 3 months, 6 months, 1 year, and subsequently annually.

(A) Tests of cognitive function

(*i*) *General intellectual level*
- (a) Raven's Progressive Matrices. A test of non-verbal reasoning ability.
- (b) Mill Hill Vocabulary Scale. A test of ability for verbal communication.
- (c) Stanford Binet Intelligence Scale. An age scale, measuring intelligence.
- (d) Wechsler Adult Intelligence Scale (WAIS). Measure of intelligence.
- (e) Porteus Maze Test. A paper and pencil performance test of foresight and planning capacity.

(*ii*) *Memory function*
- (a) Graham Kendall Memory for Designs. Test of ability to reproduce simple, geometric designs from memory, immediately after recall.
- (b) Sentence Repetition (Stanford Binet XI year Item). Test of short term memory for verbal material.
- (c) Williams' Memory Scale:
  - (1) Digit Span. Test of short term memory.
  - (2) Non-verbal Learning (Rey-Davis). This task requires the patient to learn the position of one fixed peg on each of four boards containing nine pegs.
  - (3) Verbal Learning. The patient has to learn the meanings of eight new words.
  - (4) Delayed Recall. The patient is required to recall pictorial material seen 10 min previously.
- (d) Photo Recognition (Modification of Milner's test). Test of ability to select, from twenty-four photographs of faces, the twelve which the patient was shown $1\frac{1}{2}$ min previously.
- (e) Orientation Questionnaire.

(*iii*) *Miscellaneous*
- (a) Word Fluency (Stanford Binet X year Item). To pass this item the patient must say twenty-eight words in 1 min.
- (b) Perseveration. The patient is asked to draw two circles, a cross and a square.
- (c) Reaction Time. A measure of time to react to a light stimulus, by depressing a switch.
- (d) Educational Attainments.
  - (1) Burt–Vernon Reading Age.
  - (2) Vernon Arithmetic Test.

(B) Personality and behavioural assessment

(*i*) *Questionnaires*
- (a) Cattell's 16 Personality Factor Questionnaire. A multidimensional measure of sixteen distinct primary personality factors.
- (b) Personality and Personal Illness Questionnaire (Foulds). Questionnaires measuring three levels of psychological functioning—symptoms, attitudes and personality.
  - (1) Symptom Sign Inventory.
  - (2) Hostility and Direction of Hostility Questionnaire.
  - (3) Hysteroid–Obsessoid Questionnaire.
- (c) Scales designed to measure the two major personality variables of neuroticism (or emotionality) and extraversion/introversion.
  - (1) Eysenck Junior Personality Inventory.
  - (2) Eysenck–Withers Personality Inventory.

(*ii*) *Self-rating—Visual Analogue Scale*

The patient completes the scale daily, thus providing an index of change in self-rating, on such continua as Happy–Depressed and Well–Ill.

(*iii*) *Rating Scales and Checklists*
- (a) Hargreaves Nursing Rating Scale. Designed for daily use by psychiatric nurses, covering a wide range of psychopathology, with twenty-four items each rated on a 10 point scale.
- (b) Adaptive Behaviour Scale (American Association on Mental Deficiency). A behaviour rating scale for mentally retarded and emotionally maladjusted individuals, completed by nursing staff, teachers (and also by parents). Part 1 covers the individual's skills and habits in areas important in the maintenance of personal independence. Part 2 provides a measure of maladaptive behaviour, related to personality and behaviour disorders.

* Not all assessment methods are applicable to all patients.

(c) Checklist of observation of 10 min samples of behaviour. The patient is observered for a 10 min period, once or more daily. Items of aggressive, destructive behaviour are checked off, and overactive behaviour is rated.

(*iv*) *Objective measures*

(a) Mirror Drawing. This task is designed to provide a measure of tolerance of frustration. (Time spent on task, and number of items attempted.)

(b) Pursuit Rotor. On this tracking task, the patient has a number of trial runs, at different speeds. Then, he is encouraged to adjust the speed himself (providing a measure of choice of level of difficulty).

Next, the speed is fixed at a moderate rate, and the buzzer switched off (feedback). A series of false 'success' readings are given, followed by a series of 'failure' readings. This is alternated for dominant/non-dominant hand and for several different patterns.

This provides a differential measure of the patient's persistence when succeeding and failing.

(c) Gibson Spiral Maze (Modification). The patient is required to trace a path through this circular maze, using his non-dominant hand. The test is administered under three conditions: (1) the patient is left alone to complete the task; (2) the patient is stressed every 15 sec, to increase his speed; (3) the patient is stressed every 15 sec, to increase his accuracy.

Variation in time taken and number of errors provides a measure of reaction to a mildly stressful situation.